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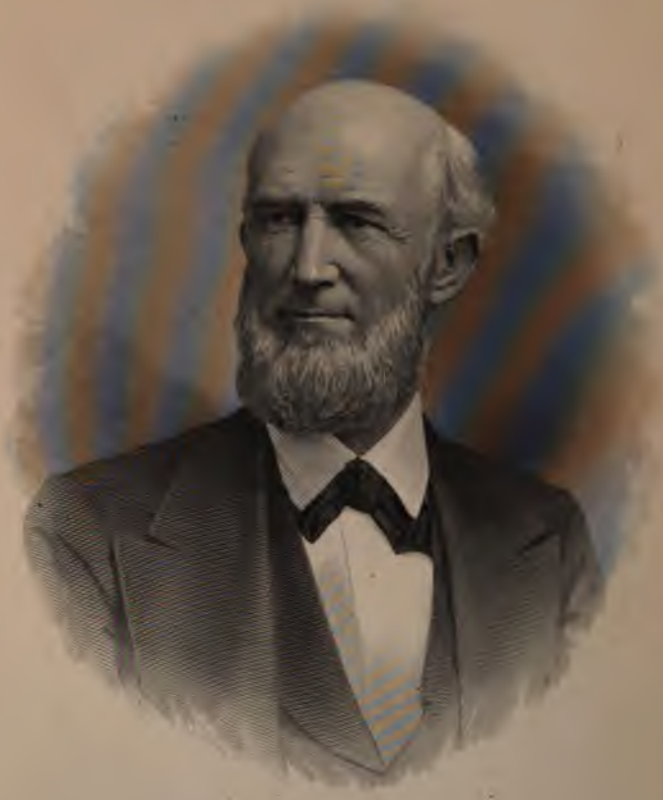
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Jas. B. Eads

American Bank Note Co. New York

A

HISTORY OF THE JETTIES

AT THE

MOUTH OF THE MISSISSIPPI RIVER.

BY

E. L. CORTHELL, C. E.,

CHIEF ASSISTANT AND RESIDENT ENGINEER DURING THEIR CONSTRUCTION

SECOND EDITION.

NEW YORK:

JOHN WILEY & SONS,

15 ASTOR PLACE.

1881

- 155-24 -



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1880,
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DEDICATION.

To Ulysses S. Grant and Rutherford B. Hayes, Presidents of the United States; to the Heads of Departments, and to the Senators and Representatives of our National Congress, through whose wise statesmanship, sound judgment and equal justice, those laws were enacted and executed under which the jetties at the mouth of the Mississippi River have achieved beneficial results of such vast importance to the welfare of our whole country, this volume is respectfully dedicated by

THE AUTHOR.

OFFICE OF JAS. B. EADS, CIVIL ENGINEER,
Room 502, Chamber of Commerce Building, Third and Chestnut Sts.,
ST. LOUIS, *September* 15, 1880.

To MR. E. L. CORTHELL, *Civil Engineer.*

My Dear Sir:—I have read the manuscript of your history of the jetties as carefully as my numerous and pressing engagements will permit, and I believe that it gives a correct, careful, and complete account of the various matters connected with the enterprise, from its inception to its completion, including full details of the construction of the work.

The very important position which you held during the entire construction of the jetties, and the valuable services rendered by you in securing their success, inspire the hope that your literary labors in connection with them will be fully appreciated and rewarded.

Very sincerely yours,

JAS. B. EADS.

PREFACE.

HAVING been connected with the jetties at the mouth of the Mississippi River for five years, as chief assistant and resident engineer, I place the history of the enterprise on record, being led to do so not only by a conviction of duty, but by an affection for the great work on which I have been engaged.

I do it not only for those who have been personally and professionally interested in the jetties, but also for the inhabitants of the great valley, whose agricultural and commercial interests have been so largely benefited by their construction, and still further, for every human being on this continent and in the old world, to whom directly or indirectly may come the beneficent influences of the Mississippi jetties.

E. L. CORTHELL.

CONTENTS.

CHAPTER I.

PAGE

Introduction—The River—Its Tributaries—Necessity for a Commercial Outlet 1

CHAPTER II.

The Delta—History—Growth—Regimen 8

CHAPTER III.

Attempts to Improve Navigation at the Mouth of the Mississippi River—Fort St. Philip Canal Project—Biographical 17

CHAPTER IV.

Civil versus Military Engineers—Canal and Jetties—Discussions before Congress—Appointment of Commission 25

CHAPTER V.

European Jetties 50

CHAPTER VI.

Report of the Board—Passage of the Act Authorizing the Construction of Jetties at South Pass 60

CHAPTER VII.

PAGE
South Pass—Location of Jetties—Construction..... 69

CHAPTER VIII.

Construction—Description and Progress of Works at the Mouth of South Pass, from June, 1875, to June, 1876..... 81

CHAPTER IX.

Advisory Board—Results of Works—Financial Embarrassments—Government Engineers..... 92

CHAPTER X.

Head of the Passes—General Conditions Described..... 110

CHAPTER XI.

Details and Results of Works at the Head of the South Pass, 1876–1877.. 123

CHAPTER XII.

Development of Jetty Channel—Twenty Feet Channel Obtained—Effects of Wing Dams..... 142

CHAPTER XIII.

Financial Embarrassments—Description of the Dredge-Boat *G. W. R. Bayley*—Twenty-two Feet Channel Secured—Report of Commission —Congressional Action..... 155

CHAPTER XIV.

Head of the Passes—Works Described—Final Results Given, 1877–1879.. 175

CHAPTER XV.

Work Delayed by Yellow Fever—Consolidation of Sea Ends of Jetties by Concrete and Crib Work—Report of Commission and Passage of Amendatory Act..... 186

CHAPTER XVI.

PAGE
Final Results..... 210

CHAPTER XVII.

Permanency of Works and Results..... 224

CHAPTER XVIII.

Conclusion..... 239

APPENDIX.

No.		Page	See Page
I.	Extracts from Report upon Fort St. Philip Canal and Jetties by Board of Engineers, January 13, 1874	243	21
II.	Report of Board of Engineers, advocating Construction of Jetties, January 13, 1875	251	60
III.	The Grant from the United States, authorizing the Construction of Jetties at South Pass	261	65
IV.	Proceedings of the Advisory Board of Engineers	266	92
V.	Estimate of the Detailed Cost of One Cord of Mattress-work	275	91
VI.	Table of Depths in line of deepest Water in the Channel at the Mouth of South Pass	276	94, 212
VII.	Table of Interruptions to Contour Lines in Channel	277	94, 212
VIII.	Letter of Mr. Eads to the Secretary of War, calling attention to Official Interference with his work, May 23, 1876	278	103
IX.	Estimate of the Detailed Cost of Construction of Dam No. I., at Head of South Pass	296	127
X.	Report upon Jetties and Questions relating to the Head of the Passes, by Board of Engineers, Nov. 19, 1876.	297	142
XI.	Letter of Mr. Eads to the Secretary of War, asking to be furnished promptly with facts relating to his work, April 19, 1877	304	107
XII.	Letter of the Secretary of War to Congress, submitting a Statement of Mr. Eads relative to Work and Payments, May 14, 1878	309	168
XIII.	Letter of Gen. A. A. Humphreys, Chief of Engineers, U. S. A., to Hon. E. W. Robertson, to show that Jetties were unsuccessful, May 1, 1878	320	171
XIV.	Review by Mr. Eads of the Letter of Gen. Humphreys, June 1, 1878	325	172
XV.	Estimate of Detailed Cost of the Construction of the Sill across Pass à Loutre	331	177
XVI.	Final Estimate of Materials in all Works	332	183, 209
XVII.	Table of Navigable Depths that can be carried through each 2,000 feet in Jetty Channel	333	192, 212
XVIII.	Report of a Board of Engineers, January 23, 1879	335	191

No.		Page	See Page
XIX.	Review by Mr. Eads of the Report of the Board, of January 23, 1879	357	194
XX.	Amendatory Act, March 3, 1879	368	203
XXI.	Table showing Scour and Deposit seaward of Jetties on Area of 178 Acres, 1875–1879	370	220
XXII.	Table showing Changes in Gulf Bottom, on Fan-shaped Area	372	221
XXIII.	Table showing Rate of subsidence of Concrete Blocks	374	228
XXIV.	Record of Navigation of South Pass	375	235
XXV.	Employés deserving honorable mention	376	240
XXVI.	Geographical, Hydrometrical, Meteorological	377	

INDEX OF ILLUSTRATIONS.

FULL-PAGE PLATES.

No.	DESCRIPTION.	Facing Page	See Text Page
1.	Basin of the Mississippi River	4	4
2.	Ancient Map of the Delta of the Mississippi River	8	8
3.	Cross-Sections of the River and Passes	14	14
4.	Map of the Delta of the Mississippi River from the U. S. Coast Survey	16	16
5.	Map of the Delta of the Danube and the Sulina Mouth, and Cross-Sections of the Jetties	52	52
6.	Mattress Ways, in Plan and Elevation	78	78
7.	Mattress, in Plan and Section	80	80
8.	Sheet Piling and Driver ; Two Elevations	84	84
9.	East Jetty, Cross-Section	86	86
10.	Jetty Channel, Comparative Cross-Sections, 1875–1876	94	94
11.	Profile of Bar, Comparative, 1875–1876	94	94
12.	East Dyke, Head of the Passes, Cross-Section	114	114
12.	Dam No. 1. " " "	114	124
12.	Lighthouse Dyke, " " "	114	178
13.	Island Dyke, " " "	136	181
13.	Island Dam, " " "	136	135
13.	Upper Dam, " " "	136	182
14.	Dam at Grand Bayou, Cross-Section	140	140
15.	Chart of Entrance Channel, Head of South Pass, April 25, 1880.	184	184
16.	Concrete Mixer, Plan	190	189
17.	East Jetty, Two Cross-Sections	202	202
18.	Pier Head, East Jetty, Cross-Section	208	208
19.	Bird's-Eye View of Port Eads and Jetties	210	210
20.	Jetty Channel, Comparative Cross-Sections, 1875–1879	212	212
21.	Profile of Bar, Comparative, 1875–1879	212	212
22.	Graphical Exhibition of Work Done and Works Obtained at Jetties	214	213

No.		Facing Page	See Text Page
23.	Comparative Chart of an Area of 178 Acres Seaward of Jetties, 1875–1879	220	220
24.	Comparative Chart of Fan-Shaped Area Seaward of Jetties, 1876–1879	220	220

FOLDED PLATES.

DESCRIPTION.

No.		See Text Page
A.	Map of the Mouth of South Pass, U. S. Coast Survey, 1875	71
B.	Map of the Head of the Passes, U. S. Coast Survey, 1875	112
C.	Concrete Mixer, End Elevation	189
D.	Concrete Mixer, Side Elevation	189
E.	Concrete Mould (Plan and Sections) and Palmetto Crib (Plan and Sections)	190 and 207
F.	Map of the Mouth of South Pass, U. S. Engineers, 1879	211
G.	Map of the Mouth of South Pass, Comparative, 1875–1879	213
H.	Map of the Head of the Passes, U. S. Engineers, 1879	122
J.	Map of the Head of the Passes, Comparative, 1875–1879	183
K.	Plot of Curves showing Changes in Seaward Face of the Bar—Gauge of the Mississippi River at Carrollton—Currents—Sediments and Tides at Port Eads, and Prism of Material Removed in Jetty Channel	217

The Mississippi Jetties.

CHAPTER I.

INTRODUCTION—THE RIVER—ITS TRIBUTARIES—NECESSITY FOR A COMMERCIAL OUTLET.

There is scarcely a civilized nation in the world whose interests are not more or less deeply affected by the Mississippi Jetties.

They have created, and will forever maintain, a deep and safe outlet for the most important river system on the face of the globe.

Some idea of the grandeur and magnitude of the valley, whose commerce has been released by the completion of the Jetties, may be formed from the following brief extracts from an address delivered by their projector, thirteen years ago, at the request of the Merchants' Exchange of St. Louis, to the River and Harbor Convention:

"The improvement of the Mississippi River involves the contemplation of one of the sublimest physical wonders of a beneficent Creator. The boundless reservoirs which supply its channels through such long periods of the year, and make it so valuable to man, and which, if opened simultaneously, would overwhelm the valley and mar its usefulness, are, with that thoughtful care, which orders all things wisely, unlocked in beautiful succession, month after month, by the touch of Spring, as she leaves her home in the tropics to bless the colder regions of the North.

"This giant stream, with its head shrouded in Arctic snows,

and embracing half a continent in the hundred thousand miles of its curious net-work, and coursing its majestic way to the Southern gulf, through lands so fertile that human ingenuity is overtaxed to harvest their productiveness, has been given by its Immortal Architect into the jealous keeping of this Republic.

"The garden, which it beautifies and enriches, contains seven hundred and sixty-eight million acres of the finest lands on the face of the globe; enough to make more than one hundred and fifty States as large as Massachusetts; acres of the choicest soil in profusion, sufficient to duplicate England twenty-four times over; more territory than the areas of Great Britain, France, Spain, Austria, Prussia, European Turkey and the Italian Peninsula combined.

"If peopled as Belgium and the Netherlands are, and with not half the danger of famine, it would contain four hundred millions of souls—nearly one third of the entire population of the world. Human comprehension cannot grasp the grandeur of such an empire. Human wisdom cannot estimate the wonderful value of such an inheritance.

"This great valley lies between those parallels of latitude that are known to be most conducive to health and to the development of the mental and physical energies of man. In its capacity to produce the cereals, grasses, cotton, sugar, tobacco, hemp, vegetables and fruits of every kind; in the richness and variety of its mineral wealth, the grandeur and value of its forests, its inexhaustible quarries; in a word, in all the natural resources which conspire to increase the wealth and power of a people, the bounty of Providence has been most wonderfully manifested.

"The stream which in every direction penetrates this favored region, and is the grandest natural feature of North America, holds in its embrace the destinies of the American people. Sooner or later it must give to the dwellers within

this valley, power and dominion over this whole immense continent.

"It is the great arterial system of this Republic. Its vital branches and wonderful reticulations permeate and envelop the great body of our country, giving unity to amplitude, value to productiveness, and to the State, resistless power and an existence as enduring as human liberty and intelligence. Through its copious channels, for all time to come, are destined to circulate the sustenance and abundance of its people."

The commerce of this great empire will, in time, certainly exceed that of any other in Christendom; and the mouth of the great river constitutes the only natural gateway through which the immense products of that region will henceforth find their way to the various nations of the earth.

These facts are quite sufficient to clothe with deep interest everything relating to the removal of the natural obstructions which have hitherto imprisoned the vast and increasing commerce of the Mississippi Valley.

The motives, however, which have prompted the publication of this history of the Jetties, are—their novelty as an engineering work; the peculiar circumstances surrounding their inception; the interesting scientific controversy which attended every step of their progress, and the highly instructive results which they have furnished to the science of Civil Engineering.

A brief description of the chief drainage basins of the Mississippi Valley will enable the reader to form a better idea of the immense volume of water and earthy matters discharged at the mouth of the river, which had to be placed under complete control by the works of improvement to insure the effectiveness of the Jetties and the permanency of the new channel.

Each principal tributary of the Mississippi River has its

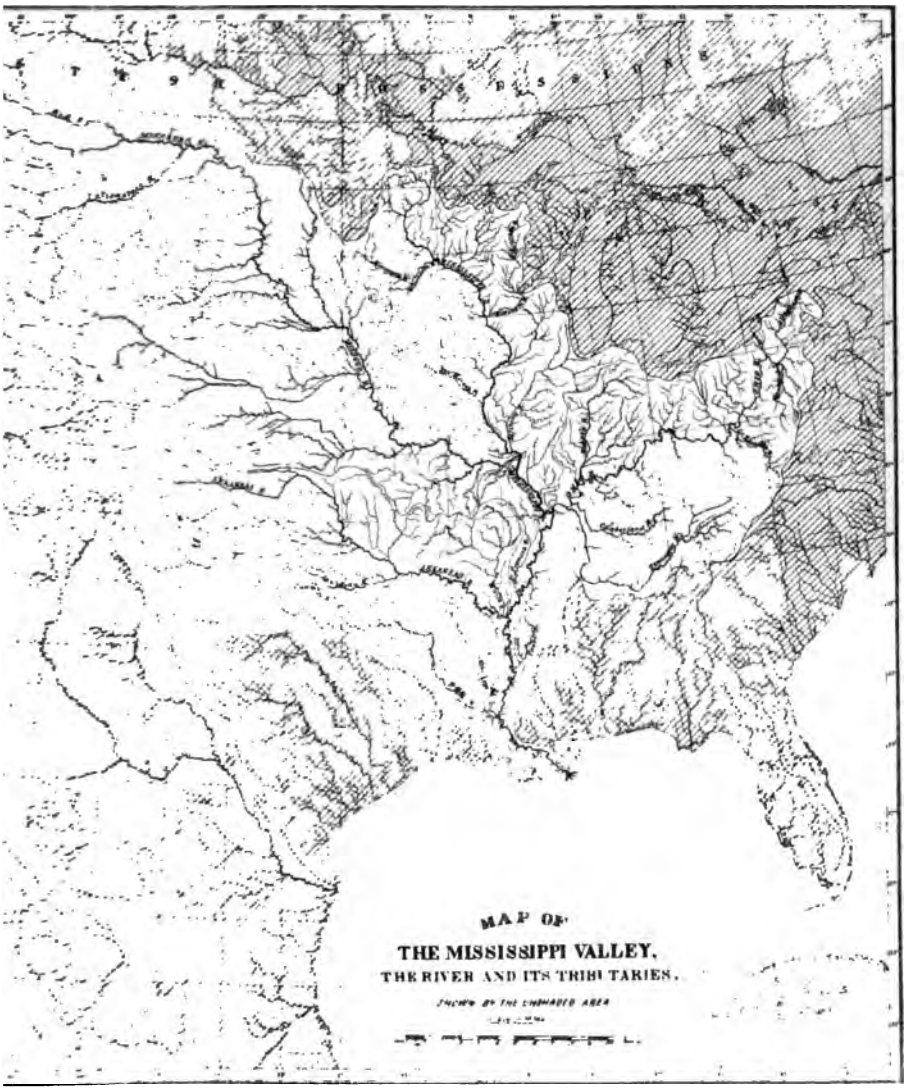
distinctive characteristics, in reference to extent of territory drained, rainfall, velocity and volume of its water, and its alluvions.

The Missouri rises on the eastern slope of the Rocky Mountains. It drains by its upper branches the distant Territories of Wyoming and Montana and a portion of the British Possessions. Its tributaries water a fertile country, which for ages has been the home of the Indian and the buffalo, but is now fast filling up with a hardy and industrious population, and promises to become the future granary of the continent. It is rich, not only in agricultural products, but in timber, coal, iron, and precious metals. Navigable for more than two thousand miles, the Missouri flows through a country of magnificent mountain scenery, "America's Wonderland." After its confluence with the Yellowstone it becomes a deep stream. It flows through Dakota, Nebraska, Kansas and Missouri, and throws its turbid waters into the Mississippi above St. Louis. Its basin is the greatest in extent of all the tributaries, and its length is nearly three thousand miles, exceeding the entire length of the Mississippi, from Lake Itasca to the Gulf of Mexico.

The Ohio, though its length is less than that of the Missouri and its drainage area much smaller, discharges a larger volume, on account of the greater rainfall of its basin. It flows through one of the most fertile and populous regions in America. From its sources in the Appalachians to its confluence with the Mississippi at Cairo, its banks are covered with thriving cities, numerous factories and productive farms. It flows through a rich soil, underlaid with limestone and abounding in extensive mines of coal and iron, the products of which form a large part of its commerce.

The Arkansas takes its rise in the mountains of Colorado, among whose melting snows it finds its source. For the first one hundred and fifty miles it is a rushing torrent, leaping in

PLATE I.


MAP OF
THE MISSISSIPPI VALLEY,
THE RIVER AND ITS TRIBUTARIES.

The Mississippi, rising in Northern Minnesota, flows through a rich grain and lumber country, and furnishes an abundant water power to the milling towns of that State. Passing these, and carrying with it their products of grain and lumber, it is joined above St. Louis by the muddy flood of the Missouri, bearing forward the grain and provisions of the great Northwest: thence it flows past rich cities and thriving towns, until the Ohio adds its volume of water and its fleet of steamers loaded with provisions, iron, coal, and other products, and soon the heavily loaded cotton carriers become a feature of the stream. The Arkansas, the Red, and many smaller branches swell the volume of discharge to more than one million cubic feet every second, and the great river rolls, a turbid flood, down through the sugar estates, the orange groves and the rice fields of Southern Louisiana.

There was a limit, scarcely reaching the center of the Valley, beyond which, for the want of a deep channel at the mouth of the river, it was unprofitable to raise cereals. All the inland wealth of agriculture and minerals was land-locked by an obstruction that had baffled every effort for its removal. This natural blockade of commerce had forced the construction of many expensive lines of railroad over the Alleghany Mountains, from the West, Northwest, and even the Southwest, to the Atlantic seaboard.

Among the many reasons for a constantly increasing demand for a better outlet were, *First*—The rapid development of the Valley, and the impossibility of carrying its products by artificial lines of transportation.

Second—The improvements that had been made in the inland navigation of the river and its tributaries, on which for many years large sums of money had been expended by the Government; and,

Third—The increase in the size and draft of ocean vessels and the radical change which has taken place in ocean trans-

portation within the last few years, by which sailing vessels of small tonnage have been largely superseded by steamships of great capacity and speed.

The following facts are given simply as illustrations of the necessity for improving the outlet of the river.

In February, 1859, a committee from the New Orleans Chamber of Commerce visited the mouth of the river and reported, that the value of merchandise delayed at the bar was — for exportation, $5,367,339; and for importation, $2,000,000.

In this estimate no account was taken of the value of the vessels, nor of any but the leading articles of produce, nor of the cargoes of ships which had cleared and were ready for sea, but whose commanders deemed it prudent to remain at the wharves at New Orleans, until there was a prospect of getting over the bar without detention. One item of merchandise delayed at the bar was nearly 72,000 bales of cotton. Many of the vessels had been detained for weeks. A month later, there were thirty-five vessels inside the bar waiting to go out, three on the bars, and seventeen outside at anchor waiting to be towed in. From 1872 to 1877 inclusive, 417 vessels grounded and were detained at the mouth of the river, with a total detention of 12,467 hours. It was during this period that the Government made its most strenuous exertions to open the channel through the bars.

CHAPTER II.

THE DELTA—HISTORY—GROWTH—REGIMEN.

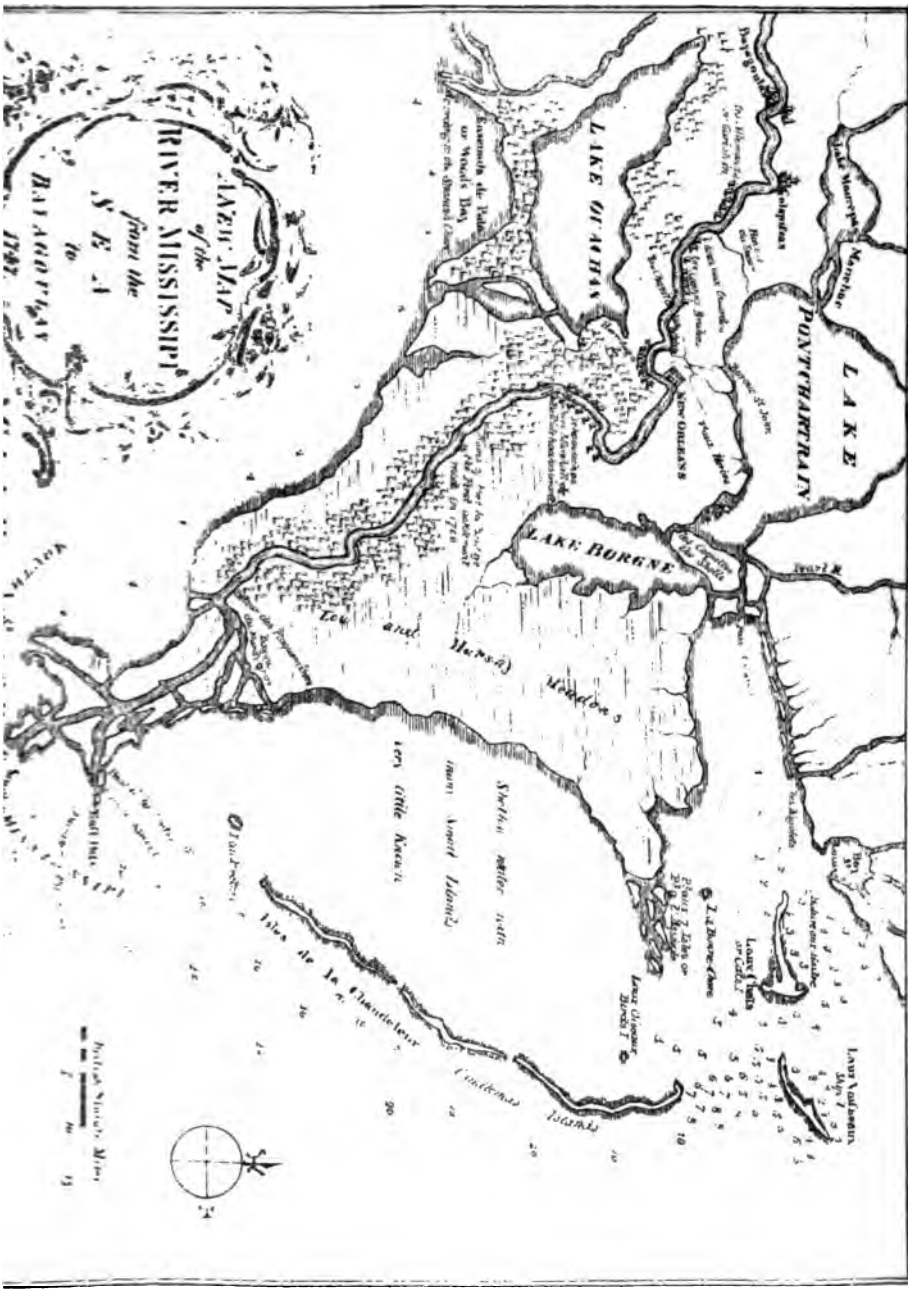
THE following ancient and unique map and description, while perhaps not accurate in geographic or historic detail, will exhibit the general features of the delta, a century and half ago.

"*An Account of the river* MISSISSIPPI, *with an accurate* NEW MAP *of that river from the sea to* Bayagoulas.

"THE River Mississippi is, next to that of St. Lawrence, the chief of all the rivers in North America, and by its easy navigation, the many fine rivers that fall into it, one of which is the Ohio, and the fruitfulness of the country on each side of it, it is preferable even to that of St. Lawrence. It takes its name from an Indian word which means, The antient Father of Rivers. It was first discovered in 1654, by our countryman Col. Wood; and, soon after the restoration, King Charles made a grant of the country on each side of its mouth, by which it empties itself into the Bay of Mexico, which grant was afterwards purchased by Dr. Cox of New Jersey, who sent two ships, and made a settlement upon it, but was not able to pursue his projects; and therefore the French, who had never discovered the mouth of this river till 1699, began in 1717, to make a settlement upon it, which they have since pursued with great vigour and success, as we now feel by their spiriting up and supporting the Cherokees against us. (See our Vol. for 1747, p. 568.)"

From other sources we gather information which somewhat conflicts with the statements made in the above descrip-

PLATE 2.


LAKE
PONTCHARTRAIN
LAKE OF MAHAN
LAKE BORGNE
NEW ORLEANS
Lake Maurepas
Manchac
Bayogoula
Mobile
Pearl R.
Lake Borgne
Lake Pontchartrain
Lake of Mahan
New Orleans
Bayogoula
Manchac
Mobile
Pearl R.
Islands
Chandeleur
Islands
Isles de la
Chandeleur
Sketch of the
River Mississippi
from the
S E A
to
Baton Rouge
1792

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tion. There is no doubt that the Spaniards discovered and possessed the delta long before the English or French occupied it. The records of their discoveries bear date of the sixteenth century.

In all the French or English records and charts of the interior of the country, of a date prior to 1680, no sign of the Mississippi River is found, although the unfortunate but daring De Soto was the first to make it a matter of history, by his enthusiastic description of the great river, as standing on the overlooking heights near Memphis, it suddenly flashed upon his sight in all its grandeur. This was in 1539, but the river and the delta were not thoroughly explored until 1684, when La Salle, pursuing his explorations from the upper tributaries, came down the river and encamped on the present site of the City of New Orleans. On the 6th of April, of that year, he arrived at the head of the passes, and found at that time three great outlets. He took possession of the mouth of the river and all its tributaries, and maintained the claim from Pittsburg to the Rocky Mountains. In honor of Louis XIV., the king, he called this vast possession, Louisiana, and named the river St. Louis. De Soto had called it "Espiritu Santo." The Spaniards knew it as "Escondido Rio Grande." The Indians gave it various names, one of which was "Mechacebe" from "*Mecha*" great and "*cebe*" river. This the French corrupted into "Mississippi."

In reference to the changes in the conditions of the Mississippi River in the past ages, we have but little reliable information. While this may not be of importance to a complete understanding of the subject, yet it is of interest. At present the Mississippi is essentially a muddy river, but there is no doubt that formerly it was comparatively a clear stream. There is every indication that five thousand years ago, a spur of the Ozark Mountains, between St. Louis and Cairo, presented a barrier to the river three hundred feet

high, and that the surface of the great lake thus formed was at the level of Lake Michigan, and connected with it; that the extensive prairies of Indiana, Illinois, Iowa and Missouri were once covered by this inland sea, and that the rich soil, which characterizes these States, was formed by the sediment brought down by the Missouri and other tributaries. There are also indications that the Ohio River was obstructed by similar mountain ranges. It was not until these obstructions were worn away, as the St. Lawrence is now slowly wearing away its obstruction at Niagara Falls, that this vast area was drained of its waters. Then the rivers fell into their natural channels. The immense amount of sedimentary matter from the Missouri and Ohio came down through the present alluvial region of the main Mississippi, and commenced that rapid and extensive delta formation which we now find at the mouth of the river, after filling up the estuary, about thirty miles wide, which extended more than one thousand miles into the country.

Judging from the mean annual growth of the delta into the gulf, since the date of the earliest reliable charts, it would seem to be not much over 4,400 years old.

The original mouth of the estuary of the Mississippi could not have been far from the coast line east and west of it, and thus the prolongation of the river into the gulf has been about two hundred and twenty miles. Until a recent age, it had advanced in comparatively deep water, until it reached the head of the passes, and from that point the descent into the gulf is much more rapid. The late examinations of the United States Coast Survey show that, nine miles off the mouth of South Pass, the water is six hundred feet deep, and twenty-five miles off, three thousand feet deep, while depths of two and a half miles have been found in some portions of the gulf.

The process of the delta formation should be described,

and the causes that produced the obstructions to commerce at the mouth of the river should be briefly stated, that the history of the attempts to remove them may be intelligible, and the discussions that followed these attempts, looking to a permanent improvement of the channel, may be understood. This important fact is before us at the outset, that, while the depths of water in the river are from fifty to two hundred feet, yet between the river and the Gulf of Mexico, around the whole cordon of the delta, there is a shoal ground over which, in its natural condition, the maximum depth is not over thirteen feet.

From the confluence of its last tributary—the Red River—three hundred miles above its mouth, the Mississippi is deep and comparatively narrow. At New Orleans it has a depth of more than one hundred and fifty feet, and a width of half a mile. The deep and narrow channel extends to within fifteen miles of the gulf, when it gradually widens to a mile and three-quarters, and its depth diminishes to about thirty feet; it here separates into three channels or outlets, throwing them out like tongues into the sea.

At the mouth of each of these passes the waters spread out to the right and left over a full half circle. Between the passes are wide, shallow embayments. The river is the carrier to the sea of the washings from the mountain slopes, the plains and prairies of the great valley. With the principles that govern the flow of its waters, especially as far as they relate to the sedimentary matter in them, we are directly concerned.

It may be stated as a well established fact, that other conditions being the same, the amount of sediment transported depends upon the velocity of the current. The river is able to carry a certain quantity of solid matter in suspension, and if at any time it is not burdened with this amount, it will pick it up from the bed and banks, but once loaded to the ca-

pacity given by its velocity, it refuses to take a greater burden, and flows against its banks and over its bed without eroding them.

The river has power given it for work, just the same as the waterfall has power to move the wheels, or the steam engine to accomplish mechanical effects; the same principles of dynamics govern all these forces. The river, by the velocity of its current, has a constant power to transport solid matter to the sea; the greater the velocity the greater the power.

There are, however, other minor causes at work. The irregular course of the river and its uneven bed, while they retard the currents by frictional resistance, assist in giving vertical motion to the particles of suspended mud and silt, as a whirlwind by its upward motions often carries aloft heavy substances and transports them long distances. Yet it is also a fact, well proven, that even in the smooth, straight artificial channels of canals and mill races, substances that are heavier than the water will, if forced to the bottom, in a short distance rise to the surface. It is a common occurrence at times of flood river on the Mississippi, in places where no irregularities exist, to see water come from near the bottom to the surface, loaded with a heavier and coarser sediment than any that is floating there.

Thus the river, by its horizontal currents and its vertical eddies, by its whirls and boils, transports the mountains to the sea. At first the rocks come tumbling down into the creek and cañon beds; broken by the fall, the dashing torrent rolls them onward, wearing off the sharp corners and loosened portions, grinding the rocks into gravel, wearing the gravel into sand, rolling over and over the sand from one bar to another, until disintegrated, worn, and ground to an almost impalpable powder, the river sweeps it out into the gulf, to be distributed by its ceaseless currents over its vast basin.

Thus forever the river is at work, striving to maintain its

channel by transporting to the sea the solid matters which the rains pour into it through its numberless tributaries.

At extreme high water the Mississippi River transports to the sea 1,210,000 cubic feet of water and 2,000 cubic feet of sold earth in suspension per second.

At extreme low water the volume discharged is about 250,000 cubic feet per second, and the ratio of sediment to water is then very small. It is during the flood season that the bars at the mouths of the three passes are pushed out into the gulf at the approximate rate of 300 feet per annum at Southwest Pass, 260 at Pass à Loutre, and (formerly) 100 feet per annum at South Pass.

When the muddy waters leave the land's end at the mouth of the passes, and begin to spread out over the submerged banks and shoals forming in advance, the current, which has all through the passes flowed at a rapid and uniform rate in a deep and stable channel, gradually loses its velocity and drops its load of sediment. As the flow of the water expands more and more to the right and left, the depths in the channel going seaward continually decrease, as the frictional resistance increases, until the crest of the bar is reached, where the depth is the least. At Southwest Pass the normal depth is about 13 feet, at Pass à Loutre 11 feet, and at South Pass 8 feet. This depth varies little during the year, or from year to year, unless changes of importance occur in the pass itself.

At South Pass the upward slope from the land's end to the crest of the bar was at the rate of one foot in four hundred; the slope from the crest to the deep waters of the gulf was one in sixty. The distance of the crest of the bars from the land's end also varies with the volume of water flowing in the pass. At Southwest Pass it is five miles, and at South Pass two and a quarter miles. The material composing the bars is a very fine sand mixed with clay.

The gulf into which the river pours its annual floods is a great inland sea of salt water. The range of the tides is very small, not averaging over fourteen inches, and along the face of the delta they occur but once in a day. At flood river the fresh water pushes the salt water out of all the river channels and passes, and away from the mouths of the passes, even to the outermost crest of the bars, and then flows through a bed of salt water, gradually widening until it becomes a thin, light brown sheet, whose line of demarkation with the green salt water is clearly defined and can be seen many miles from land. The river thus continually pushes out its bars into this almost tideless sea, which in turn by its waves, tides and littoral currents, exerts a leveling and eroding influence upon them, especially in low-water season.

To complete this general description it is necessary to state a few facts of minor importance.

The range between high and low water of the lower Mississippi is as follows: at the mouth of the Ohio it is 52 feet; at Natchez, 375 miles above its mouth, 51 feet; at New Orleans 16 feet, and at the head of the passes 2¼ feet.

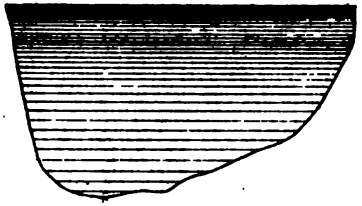
At Natchez, the fall per mile at high water is about 3.2 inches; New Orleans to Red River, 1.85 inches; head of the passes to Quarantine, 1¼ inches; through the Southwest Pass, 2 inches; and through the South Pass, 2¼ inches.

At New Orleans the velocity is about 6 feet per second, and at the head of the passes about 5 feet per second.

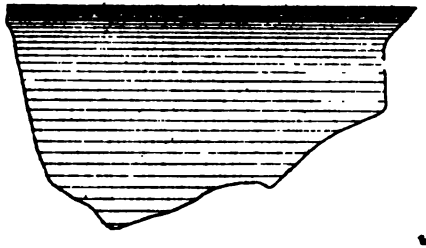
At extreme high water the surface of the river is several feet above the whole alluvial basin, and nothing but the levees built along the banks prevent a general overflow. For a distance of thirty-five miles above the mouth of the river, the country is inundated during every high-water season, and within five or six miles of the mouths of the passes, the low, marshy banks, even at low river, are covered by the tidal overflows.

PLATE 3.

S.W. PASS.



PASS À L OUTRE



SOUTH PASS



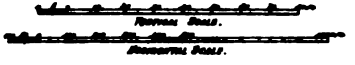
SECTIONS

OF

MISSISSIPPI RIVER

AND THE

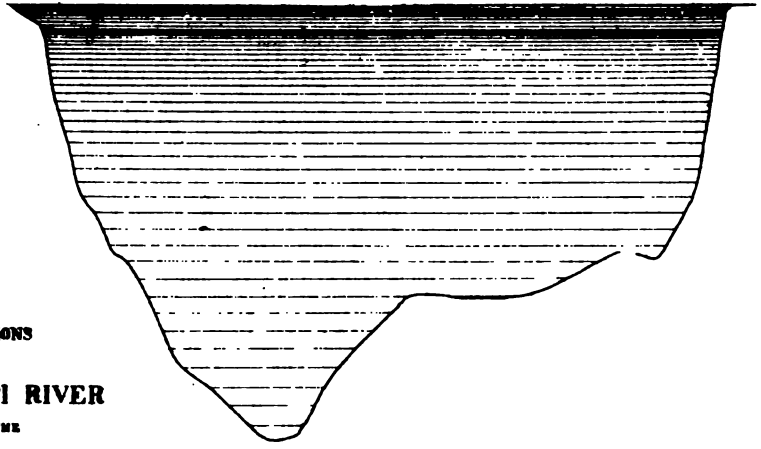
PASSES



VERTICAL SCALE.

HORIZONTAL SCALE.

MISSISSIPPI RIVER AT Fr St PHILIP




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wing is a table of the dimensions of the main
e Mississippi:

	Length to Outer Crest of Bar.	Mean Width.	Mean Depth.	Mean Area of Cross-section.	Proportional Discharge.
	Miles.	*Feet.*	*Feet.*	*Square Feet.*	
.....	17	1,500	40	60,000	0.45
.....	15	1,900	36	69,000	0.45
.....	12½	700	34	24,000	0.10

eft bank of the river, three miles above the head
es, Cubitt's Gap—a crevasse, formed in 1863—dis-
volume into the adjacent bay about equal to that
'ass.

th across the bar at Southwest Pass, from eighteen
in the pass to the same depth in the Gulf, is one
rter miles. At South Pass it was one and three-
iles. The length along the crest of the bar at
Pass over which it discharges its volume, is two
rter miles, and at South Pass it was about one

roximate amount of solid matter discharged annu-
e river is 276,718,933 cubic yards, equivalent to
e mile square and 268 feet high.

l wave approaches the mouth of the Mississippi
utheasterly direction, and creates a current past
which varies from 0.3 of a foot to 2.5 feet per sec-
mean being about 0.5 of a foot.

uds exert an important influence; they have the
ses of the northeast trade winds.

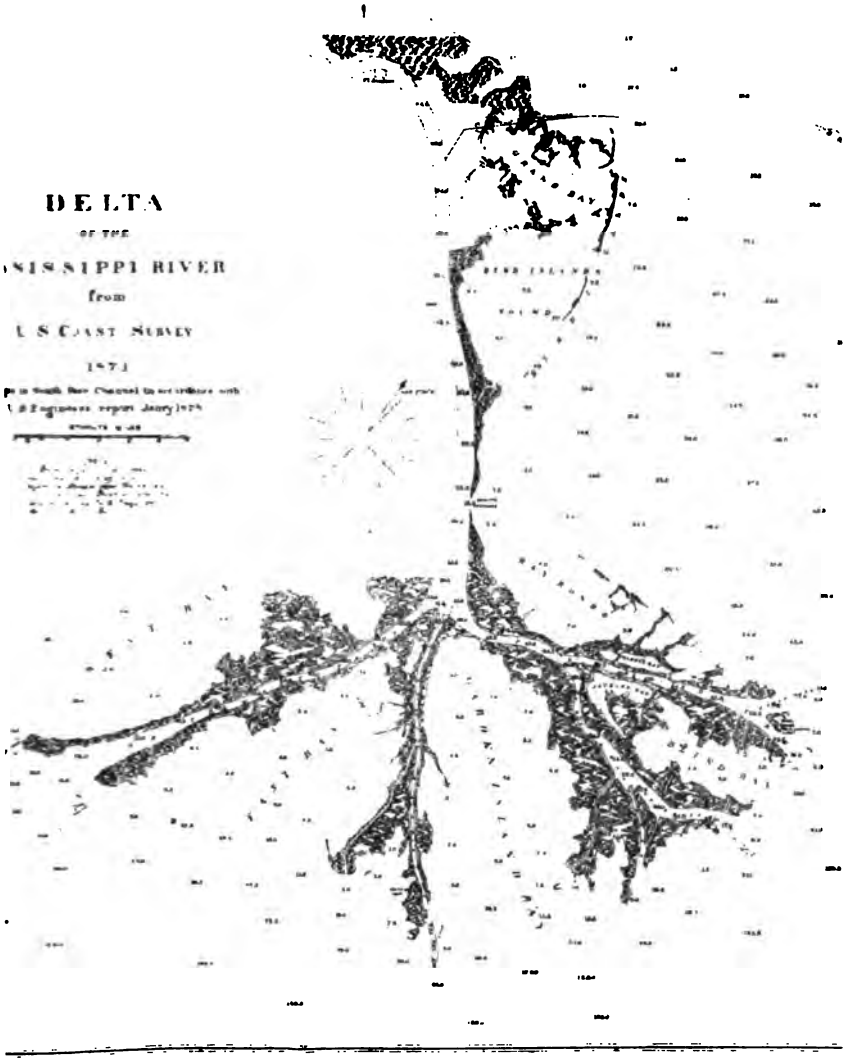
these important facts are taken from Humphreys
's elaborate report.

s found at the mouth of the passes a peculiar phe-

nomenon called "mud lumps," or islands, which are pushed up above the surface of the water near the crest of the bars; they rise sometimes ten or fifteen feet above the water, and vary in size from a few feet in diameter to an area of thirty acres. They are formed either by gaseous forces or by the pressure of the advancing bars. The material composing them is a sticky clay, although a close analysis shows over sixty per cent. of mineral silt.

The foregoing disconnected facts, and incomplete description of the delta and its bars are here given, to be supplemented in succeeding chapters by a more definite and concise description of conditions, causes and forces.

PLATE 4.



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CHAPTER III.

ATTEMPTS TO IMPROVE NAVIGATION AT THE MOUTH OF THE MISSISSIPPI RIVER—FORT ST. PHILIP SHIP-CANAL PROJECT—BIOGRAPHICAL.

ATTEMPTS were made, as early as 1726, to deepen the channel at the mouth of the Mississippi River, by dragging iron harrows over the bars; but the history of the efforts of the United States Government to remove these obstructions to commerce dates back only to 1837, when an appropriation was made by Congress for an extended and accurate survey of the passes and bars, and for deepening the channels by dredging with buckets, a plan which had been recommended by a board of United States Army Engineers. The appropriation was small, and was exhausted in surveys and preparations for the work. No other attempt was made until 1852, when $75,000 was appropriated. A board of army officers appointed at that time was instructed by the War Department to report a plan of operations. The board recommended:

"*First.*—That the process of stirring up the bottom by suitable machinery should be tried.

"*Second.*—If this failed, that dredging by buckets should be tried.

"*Third.*—If both these modes failed, that parallel jetties should be constructed, five miles in length, at the mouth of the Southwest Pass, to be extended into the gulf annually, as experience should show to be necessary.

"*Fourth.*—Should it be then needed, that the lateral outlets should be closed.

"Finally, should all these fail, a ship canal might be resorted to.

"The recommendation of the board to dredge by stirring up the bottom was approved by the War Department, and a contract was accordingly entered into for deepening the Southwest Pass to eighteen feet. The contract was successfully executed, and a depth of eighteen feet obtained in 1853. No further appropriation was made until 1856, and, as anticipated, no trace of the former deepening was left.

"In 1856, $330,000 were appropriated for opening and keeping open by contract ship channels through the bars at the mouths of the Southwest Pass and Pass à l'Outre." (See Humphreys and Abbot's Physics and Hydraulics of the Mississippi River, p. 486.) A contract was awarded to Messrs. Craig & Rightor, for opening both passes twenty feet deep and three hundred feet wide, and for maintaining that channel four and one-half years. They constructed on the east side of Southwest Pass, a jetty about a mile long, built of a single row of sheet piling, which, with the assistance of harrowing and dredging, deepened the channel to eighteen feet. Failing to complete their contract, the Government continued the work with the remainder of the appropriation, and the depth of eighteen feet was maintained at both passes during part of the years 1859–'60. No attempt was made to open the channel during the war.

In 1868–'69 the Government constructed a steam propeller dredge, at a cost of $350,000 [Appendix 1]. The propeller stirred up the mud at the bottom and threw it to the surface by means of a deflector behind the propeller, the object being to have it carried away by the currents. A second boat of similar plan was built soon after. These boats were in almost constant use for three years. A board of army engineers

gave their opinion, in the winter of 1873, that the results obtained did not warrant them in estimating that a greater depth than eighteen feet could be maintained by dredge boats.

All the methods employed from 1837 to 1875 were simply a contest with the depositing forces of the river and the wave forces of the gulf. The channels which had been opened during the season of low river, when the water was free from sediment, often filled up suddenly when the floods brought down upon the bars the enormous quantity of solid matter with which they were loaded. After months of persistent scraping or dredging, a severe storm, sweeping the waves across this artificial channel, often filled it up in a few hours with the heavy sand washed in from the neighboring reefs.

During all these years various plans for a permanent outlet were proposed by civil and military engineers. These propositions were brought before Congress for its action, but without any practical results.

As early as 1832, Major Benjamin Buisson, Chief Engineer of the State of Louisiana, designed a plan for a ship canal at a point a few miles below Fort St. Philip, to connect the Mississippi River with the waters of Breton Sound. He submitted his plan to the State Legislature. They approved it and adopted the following resolution: "Resolved by the Senate and House of Representatives of the State of Louisiana, in General Assembly convened, that our Senators and Representatives in Congress be requested to bring to the notice of the General Government the probable practicability of such a work" (a ship canal connecting the Mississippi River with Breton Sound), "and to urge an early estimate and survey of the same by competent officers."

A survey was ordered and reported to Congress by the War Department in 1837. In that year Major W. H. Chase presented the first well-defined plan for a ship canal. His estimate for its construction was $10,000,000, a sum entirely too

large to be appropriated at that early day for any public improvement. In 1852 a mixed naval and engineer board was convened. The members of the board were Com. W. K. Latimer, U. S. N., Major W. H. Chase, U. S. A., Capt. J. G. Barnard, U. S. A., and Capt. G. T. Beauregard, U. S. A. They recommended that the appropriation of $75,000 available at that time should be expended in stirring up the bottom, and, in recommending another appropriation, advised that, if dredging should prove a failure, the appropriation of $150,000 should be expended in the construction of jetties at Southwest Pass, and in their report stated that the "project of jetties is based upon the simple fact that, by confining the waters, which now escape uselessly in lateral directions, to a narrow channel, the depth of this narrow channel must be increased—in other words, the existing bar must be cut away." The board concludes by saying, that should these plans fail, a ship canal could be resorted to. (See Annual Report Chief of Engineers, U. S. A., for 1874, Appendix R, p. 69.)

In 1858 Mr. R. Montaigu, a civil engineer, revived the idea of a ship canal, which had virtually been slumbering for twenty years. He made plans and estimates, using the information obtained by Buisson and Chase, and made a personal examination of the site of the projected canal. He proposed to construct the work by individual subscriptions, and obtained the indorsements of the merchants and capitalists of New-Orleans. "The war and the death of the projector defeated this proposal, but, with the restoration of peace, the project of a national canal, as recommended by the Legislature of Louisiana, was brought forward under the auspices of some of the oldest and most eminent merchants. A committee of the Chamber of Commerce was appointed, which renewed the recommendation of the work and pressed its adoption upon the Government." (See Annual Report Chief

of Engineers, U. S. A., for 1874, Appendix R, p. 23.) In 1871 Congress requested the Secretary of War to cause surveys and plans to be made for a ship canal, to connect the river with Breton Sound. This work was performed by Major C. W. Howell. In 1873 a board of army officers was appointed to examine his plans, and was subsequently instructed to ascertain the feasibility of improving one of the natural outlets of the river. The members of this board were Genls. J. G. Barnard (President), John Newton, Q. A. Gilmore, G. K. Warren and G. Weitzel, Col. Wm. P. Craighill and Major C. W. Howell. After a personal examination of the site of the proposed canal, and of the mouth of the river, they made their report in February, 1874, favoring the canal scheme and opposing the jetty plan. Their objections to the jetty system were:

First.—That the jetties would be undermined at the sea ends.

Second.—That the foundation on which they would rest was unstable, and

Third.—That there would be a greatly accelerated advance of the bar after the jetties were constructed.

For these reasons they believed that it would be extremely difficult to construct the jetties, and impossible to maintain them. (See Appendix I.)

The majority report was strongly approved by Gen. A. A. Humphreys, Chief of Engineers, U. S. A., who estimated that the cost of construction and maintenance of jetties at the mouth of Southwest Pass to produce a depth of twenty-seven feet would be $23,000,000; at South Pass, $17,000,000, and of the Fort St. Philip canal, $13,000,000. In reference to the bar advance after the jetties are constructed, he says: "If the depth to be maintained is twenty-seven feet at low water, or twenty-eight feet at high water, it will be found by a similar process that the annual advance will not be less than

twelve hundred feet." (See Annual Report Chief of Engineers, for 1874, Appendix R, pp. 87 and 93.)

Gen. J. G. Barnard dissented from the report of the majority, because

First.—The plans and estimates for a ship canal were not based on sufficient or reliable data.

Second.—Dredging with suitable appliances would give twenty-two feet at high tide continuously, and this depth would relieve the pressing wants of the Mississippi Valley, and

Third.—It would be desirable to improve one of the natural outlets of the river, so that the expensive use of machinery could be dispensed with.

In reference to the adoption of the jetty system, he said: "The question submitted, however, is not so much 'to recommend its trial' as to recommend its *consideration* and that scrutiny and survey on which alone estimates can be based." Comparing the natural conditions existing at the mouth of the river with those at the mouth of the Danube, where jetties have not only been successful, but have retarded the bar advance, he considered the conditions of the Mississippi more favorable on account of the bold slope of the delta seaward, and the greater influence of the sea forces. He advised that, if the jetty plan was adopted, the works should be built at the mouth of South Pass—the cost of which, if successful, would be but a fraction of that of the canal. He closed his report with the following forcible language, which is almost an appeal for an unobstructed natural outlet: "The advantages of an open river-mouth are inestimable. The needs of a navigation so great as that which now exists, and which in the future of the great Mississippi Valley must be fifty-fold increased, demand it. It is said that 'the time has come' when the needs of commerce demand the canal; but I answer that the *time will come* when there will be the same cry for a

navigation unimpeded by locks—An Open River-Mouth—which we now hear for a canal. But in whatever aspect the question be regarded, the use of the river-mouth for the next ten years is simply inevitable. * * * It would be a rash confidence which would contemplate a realized 'Fort St. Philip ship canal' earlier than A. D. 1884." (See Appendix I.)

About the time of the earlier surveys and discussions in 1837, looking to the improvement of navigation at the mouth of the Mississippi River, James B. Eads, then a lad fourteen years of age, in straitened circumstances, and employed as a clerk in a mercantile house, spent the evenings in the library of his employer, delving in the rich mines of mechanical and engineering philosophy, storing his mind with principles and facts, and disciplining it by hard study to meet the problems in life which were before him. Later he had a practical experience with river forces, in his business of searching for and raising the wrecks of steamboats. He walked, under the shelter of the diving bell, in hundreds of places on the bed of the river in all its varying stages and conditions, and obtained accurate information by a personal contact with the water, its currents and sediment.

During the war of the rebellion he constructed for the United States Government seven iron-clad gunboats in one hundred days, though, when he commenced operations, the wood of which they were built was still standing in the forest and the iron unwrought. He then built six others wholly of iron, and made several valuable inventions for handling the heaviest guns by steam. After the war he was called upon, as a civil engineer, to deal with some of the most difficult problems ever attempted by the profession, in his successful attempts to carry the piers of the St. Louis Bridge through a hundred feet of shifting quicksand to the bed-rock, and then without staging to erect the steel arches, that

spanned the openings of over five hundred feet between the piers.

He first brought his lifelong practical knowledge and experience in river hydraulics to bear upon the great question of how to improve permanently the mouth of the Mississippi, when in May, 1873, while examining the bars at the mouth of the river, in company with a large Congressional delegation, he unhesitatingly declared that the proper way to remove the obstructions to commerce was by parallel dykes or jetties at the mouth of one of the passes.

CHAPTER IV.

CIVIL VERSUS MILITARY ENGINEERS—CANAL AND JETTIES—DISCUSSIONS BEFORE CONGRESS—APPOINTMENT OF COMMISSION.

For years the design and construction of all national works of improvement, under the control of the government, had been wholly confided to its military engineers. Mr. Eads felt assured in his own mind that it would be utterly useless for a civil engineer to attempt to obtain the control of such an important national work as this in opposition to the United States Engineer Corps, unless some extraordinary inducement were offered to the government; and more especially as the plan which he advocated was disapproved of, if not absolutely condemned by every government engineer then in the service, except General Barnard, whose position in the matter has been stated in the previous chapter.

Induced by this motive and the desire to secure to the Valley of the Mississippi a deep and untrammeled outlet to the sea, Mr. Eads, in February, 1874, made a formal proposition to Congress to open the mouth of the Mississippi River by making and maintaining a channel twenty-eight feet deep between the Southwest Pass and the Gulf of Mexico for the sum of $10,000,000, at the entire risk of himself and his associates. Not a dollar was to be paid by the government until a depth of twenty feet had been secured, when he was to receive $1,000,000, and afterward, $1,000,000 for each additional two feet, or a total of $5,000,000 when twenty-eight

feet had been obtained. The remaining $5,000,000 were to be paid in annual installments of $500,000 each, conditional on the permanence of the channel during the ten years.

This fair proposition, though perfectly safe to the government, called forth a very active opposition on the part of the Corps of United States Engineers; a civil engineer had appeared upon the stage to contest with them the right to design and execute the most important civil engineering work ever undertaken by the government. The importance of securing the advice of civil engineers in connection with this undertaking was thus forcibly stated in a speech delivered in the United States Senate, by Hon. Carl Schurz, who was one of the earliest and warmest supporters of Mr. Eads's proposition.

"Thirty-seven years ago the Engineer Department of the army took the matter in hand, and for thirty-seven years they have been planning and reporting upon the matter, and scratching and scraping at the mouth of the Mississippi, and to-day the depth of water is no greater than it was then. In other words, they have effected nothing. The population of the Mississippi Valley have long and quietly submitted to such a state of things. In the mean time they have grown in numbers; grown enormously in prosperity and productive power. They have waited long and most patiently that the engineers of the army would discover and show themselves able to carry out a plan which would make the great river what it ought to be, but they have waited in vain.

"At last, after mature consideration, such as our committee has devoted to this great subject, it is proposed to furnish new light to penetrate our councils. Having for thirty-seven years permitted the engineers of the army to control this matter—with what success I have already indicated—they insist that the genius and skill of the civil engineers of America

shall have an opportunity to compete with the army in the solution of this great problem. I desire Senators to remember the fact, that this is probably the only civilized country on the face of the globe where such enterprises are left exclusively to military engineering. Even in those European monarchies, which are so military in their character, governments would not think a moment of excluding the civil engineer from public works which are not absolutely of a military nature. On the contrary, almost all, aye, I might say all of such work, is done by the civil engineer exclusively. Why should this republic, then, rely upon the military alone? We ask for a commission of engineers to examine the different methods of opening the mouth of the Mississippi which have been proposed; we ask that the military engineers, who have occupied themselves so many years with this problem, shall have two men on that commission to represent their views; we ask that another body of government officers of recognized skill, members of the Coast Survey, shall have two members; but then we insist that the civil engineers of America, more numerous and perhaps more experienced than either—men who have planned and achieved greater enterprises than either, men who have tunneled our mountains, run our railroad tracks thousands of feet above the level of the sea, built the foundations of our magnificent bridges, and whose triumphs are among the most resplendent glories of the republic—we insist that they shall have an opportunity to offer their genius and skill to the country, and have a representation worthy of them on this commission."

The controversy created by Mr. Eads's proposition was not only personal and professional, but sectional. New Orleans and St. Louis having equal interests at stake, the one representing the Southwest, the other the West and the great Northwest, were divided in reference to the best methods of opening the mouth of the river. New Orleans had long be-

fore pronounced in favor of a ship canal, and had secured the indorsement of almost every commercial body and political convention in the Mississippi Valley. She was uncompromising in her opposition to any other plan. For a generation her orators had pictured in glowing colors the great commercial prosperity that would come when the hopes of a canal were realized, and her scientific men had proved, to their satisfaction at least, that this was the only certain method of removing the obstruction to commerce. The public had become so thoroughly imbued with this idea that when the bill for a ship canal and the proposition for the construction of the jetties were before Congress at the same time, in the spring of 1874, a most intense interest was exhibited in the discussions that took place between the advocates of each project. The contest at first was between the canal advocates in the Southwest and the United States Engineer Department on the one hand, and Mr. Eads nearly alone on the other. For while public opinion and the press in St. Louis and elsewhere in the West supported his project, his great personal popularity and success as an engineer led them to do so. They had long ago become weary of waiting for the engineers of the government to give their commerce its much needed relief, and they now turned to Mr. Eads as their exponent and leader.

The controversial arguments on abstruse subjects in hydraulics, which, under other circumstances would have been tedious and uninteresting, were by these exciting causes filled with an intense interest. They were circulated everywhere, and read eagerly by the general public.

Mr. Eads, in a letter dated March 15th, 1874, and addressed to "Hon. William Windom, United States Senate, Chairman of Committee on Transportation Routes to the Seaboard," and one of the most able and steadfast friends of the jetties, stated his views of river hydraulics as follows:

"The improvement of the mouth of the Mississippi proposed by me consists in an artificial extension of the natural banks of one of the passes, from the point where they commence to widen and disappear in the gulf, to the crest of the bar, about five miles distant.

"This method is indicated as the only proper one, by the following facts:

"The Mississippi is simply a transporter of solid matter to the sea. This consists chiefly of sand and alluvion, which is held in suspense by the mechanical effect of the current. A small portion, consisting of larger aggregations, such as gravel, boulders, small lumps of clay, and drift-wood, is rolled forward along the bottom. By far the greatest portion is, however, transported in suspension. The amount of this matter, and the size and weight of the particles which the stream is enabled to hold up and carry forward, depend wholly upon the rapidity of the stream, modified however, by its depth. The banks and bottom being chiefly sand and alluvion, are easily disintegrated by the movement of the water, hence the amount of load lost by any slackening of the current at one place, will be quickly recovered in the first place below where the current is again increased.

"The popular theory advanced in many standard works on hydraulics, to wit, that the erosion of the banks and bottom of streams like the Mississippi is due to the *friction* or *impingement* of the current against them, has served to embarrass the solution of the very simple phenomena presented in the formation of the delta of the Mississippi, because it does not explain why it is, that under certain conditions of the water, it may develop with a gentle current an abrading power, which, under other conditions, a great velocity cannot exert at all. A certain velocity gives to the stream the ability of holding in suspense a proportionate quantity of solid matter, and when it is thus charged it can sustain no more,

and hence will carry off no more, and therefore cannot then wear away its bottom or banks, no matter how directly the current may impinge against them.

"In the upper portions of the delta (which, according to some writers, extends a few miles above Cairo), the width of the river is very irregular. When a rise occurs, the current is increased in the narrow parts of the river, and the carrying capacity of the stream consequently becomes greater, and it at once takes up an additional load. When, however, as the stream flows on, it enters a wide expanse, the current is slackened and the excess of load is dropped to the bottom, and thus shoals or bars are formed. From such expansion of channel way, the volume of water, thus relieved of a portion of its load, passes into another one of the narrow parts of the channel, and here its current by contraction is again accelerated, and the increased load which it can carry is immediately scoured up from the bottom and sides of the channel. In the bends, the centrifugal force of the water makes the current more rapid on the concave bank of the stream, and there it usually gets its additional load, and the caving in of the bend testifies to the rapacity of the water at that point of its course. Once loaded, however, it can carry no more, and hence it may sweep around half a score of other bends below with equal velocity, without injury to them. If it encounter another expanse, however, it again loses part of its velocity, and with it part of its load, to be recovered again in the narrower parts of its channel below. It is evident, therefore, that if the channel were at all uniform in size, the current would be more constant, and the alternate depositing and recovery of part of the burden of the stream would be prevented. This loading and unloading is synonymous with caving banks and sand bars.

"The lower part of the river, nearly all the way from Red River to the mouths of the passes, is remarkably uniform in

, and is therefore comparatively free from falling banks
hoals. This part of the river is transporting its load
great regularity, and without interruption, to the sea;
t that above, owing to the alternating contractions and
sions in its channel, transports its burden with great
larity, dropping a part here and taking up a part there,
hus by successive stages, from season to season, it is
forward.

the volume of water were constant, it is plain that the
would soon have a current of great regularity; because
posit dropped in a wide part of the river lessens the
ity of the channel there, by shoaling it, and re-estab-
the proper velocity of current, and thus stops further
it at that place; whilst at the contracted channel the
soon enlarges the passage, and consequently reduces
rrent, and thus further scour ceases at that point.

a channel of uniform width, when the river falls, the
n occupies only the narrower parts of it, and if these be
oo great to maintain sufficient current to transport the
the excess is deposited in the channel, which is thus
r diminished until the current is thereby accelerated
proper rapidity, after which it ceases to deposit any

When the Bonnet Carré crevasse occurred, the river
it (one hundred and seven feet in depth) was shoaled
irty-one feet, because the volume of water in the river,
lessened by the crevasse, was no longer sufficient to
ain the normal current in a channel large enough to
the entire river; consequently the current below the
se slackened, and the excess of load was dropped in
hannel until the bottom was filled up thirty-one feet
with the deposit. This reduction of channel was suffi-
to re-establish the current and prevent further deposit.
e see, therefore, that the causes which control the
of the stream, and those which give to it the ability to

hold its burden of solid matter in suspense, are constantly acting in opposition to each other, and thus the equilibrium between them is restored as often as it is disturbed by alternations in volume, or by irregularities in channel.

"We not only learn from this how simple some of the most apparently mysterious phenomena of the river really are, but also how futile it would be to attempt either to enlarge or to diminish the normal size of its channel, anywhere within its alluvial bed. As rapidly as the engineer strives to deepen it without proportionately contracting it, and thus enlarges it beyond the capacity which these natural forces give it, just so rapidly will the current be slackened by the enlargement, and the deposit be dropped there, and thus lessen it again. And as fast as he may contract it, just so fast will the current be increased, and the consequent scour enlarge it again by deepening it. The *magnitude* of the channel is determined by forces which it is neither necessary or profitable for the engineer to encounter. The *form* of the channel he can control and alter. If he widen it, these forces will inevitably shoal it; if he contract it, they will just as certainly deepen it. * * *

"The phenomena presented by the protrusion of the passes of the river out into the gulf are equally as simple as those of the river above. A glance at the map shows how remarkably uniform is the width of each of them from their commencement, until they reach the neighborhood of the gulf. In the passes, and in the river for several hundred miles above, the slower shore currents have dropped their excess of load, until the shores have been built up and narrowed in to such a degree that all further deposits by them tend to increase the steepness of the banks; hence the additional deposit slides down toward the middle of the channel bed as fast as it dropped. The onward motion of the stream tends to continually draw in its waters from the shore (which is

evidenced by the driftwood flowing always in the middle of the channel of the stream); hence, the water, after depositing part of its load near the shore is again made capable of carrying it by the increase of its velocity, when it again gets near the middle of the stream, and thus the central mass of water is continually made capable of taking up from the bottom the excess of load dropped by the shore currents. At the mouth of the pass this is not the case, for the angle of rest of the deposit, or the natural slope, is not yet attained there. At the Southwest Pass, for instance, after flowing for several miles through a deep channel, with narrow and parallel banks, the stream widens out from about twelve hundred feet and a depth of sixty feet, to ten thousand feet and a depth on the center of the bar of about fifteen feet. Here the shore currents are continually dropping the surplus load, which their diminished velocity is unable to hold up, and thus the shores of the pass are being constantly built up and narrowed in, and brought to the surface of the water, where, with reed grass, marine plants, etc., they are gradually converted into dry land.

The strong central current, however, is maintained intact by the reduced depth over which the stream passes, as it expands, like a fish's tail, out to the bar. The velocity of the stream being maintained by shoaling in depth as it expands in width, it is able to transport its entire load out beyond the bar, excepting only that which it has dropped on the submerged and incipient shores of the pass. Although the current is strong out across the bar, it is soon checked because of its immense width and shallow depth, by which great friction in proportion to volume is induced. Hence the load is deposited just outside the bar, and its constant outward growth is thus assured, while the growth of the shores of the pass follow in due order.

"The fact that a given current will keep in suspension a

corresponding quantity of solid matter; that at a less velocity a portion of it will be deposited and taken up again at a greater, is fully recognized in experimental science, and has been extensively made use of for analysis of soils. An eminent investigator of this subject, Prof. E. W. Hilgard, of the University of Michigan, now of the University of California, Oakland, Cal., has classified silts according to the different velocities at which they deposit. This independent line of research fully confirms the view herein advanced in explanation of the phenomena presented throughout the alluvial bed of the Mississippi.

"It is a popular fallacy to imagine that the gulf presents a barrier to the onward flow of the stream at the mouth of the pass. On reflection, it must seem reasonable that a river should flow with less friction between walls of water than between walls of earth. At the bar the river has its banks of earth no longer, but it still flows between banks of salt water, and over a bottom of brine instead of mud. It has no longer a descent of a few inches to the mile, however, and hence must maintain its current in the gulf simply by its momentum. Friction on its sides and bottom is the agent which finally brings it to rest; but while its momentum lasts, the widening out into the sea and the final obliteration of the river will proceed very gradually.

"If from the point where the banks of the pass be twelve hundred feet asunder, and its depth sixty feet, we should artificially prolong them to the crest of the bar, still keeping them but twelve hundred feet asunder, we would inevitably have sixty feet depth at the mouth of these jetties. A thorough comprehension of the laws which control the river will banish from the mind of any one the erroneous idea that the construction of the jetties will back up the water, and thus raise it above them. It will also demonstrate that to be successful the jetties should be parallel—not converging.

"As doubling the depth doubles the current with the same inclination of surface, it must be evident that the great reduction of friction accomplished by narrowing the channel from ten thousand to twelve hundred feet will enable the momentum of the stream to be kept up to a greatly increased distance beyond the bar, and hence the river will be able to carry to greater depths, and into stronger gulf currents, that load which it is now only able to deposit just outside of the bar. That a stream will preserve its individuality for a great distance, while flowing through the sea or through another body of water, can be proven by every river which enters the ocean with a strong and consequently deep volume. The upper Mississippi preserves its identity for a score of miles after having entered the grand channel of the main river, and the dividing line which separates its clear waters from those of its more powerful neighbor can be distinctly traced, in flood time, far below St. Louis.

"If the truth be once impressed on the mind, that the river maintains for some distance a distinctive channel through the gulf, the effect of the feeble tides at the mouth will be more clearly comprehended. These average less than fourteen inches in height, and while they simply act to raise and lower the fluid channel through which the river flows after leaving the land, they really oppose no barrier to its onward progress. The average velocity of the current is maintained; the retardation due to the flood tide being compensated by the increased speed induced by the ebb.

"A careful study of the above facts should serve to banish all fear of a progressive advancement of the bar beyond the jetties. That the deposit of the river must tend to shoal the water beyond the mouth, and ultimately to fill up the gulf itself, is certain; but that it can form a shoal in front of the jetties, in this or the next generation, is scarcely possible. If the stream at the Southwest Pass be made to

emerge in a compact form from between the jetties into the gulf, it is not unlikely that its course and current will be distinctly marked fifty miles from the present bar. Even now it is said that the river current can be detected twenty-five miles from the Passes * * *."

"The solution of the problem of improving the navigation between the river and the gulf will never be satisfactorily accomplished except by jetties, and that they will ultimately be resorted to is as certain as that commerce and agriculture will increase in the valley."

Soon after the appearance of this letter, the chief of Engineers, General Humphreys, addressed a rejoinder to it, dated May 22d, 1874, which was read by the Hon. George W. McCreary in the House of Representatives. Its concluding paragraph was as follows:

"It is probably entirely unnecessary for me to say here, that the statements which Mr. Eads has made in the pamphlets he has published, concerning the conditions existing in the Mississippi River and at its mouth, are the mere revival of old assumptions, which experimental investigation has long since shown to be utterly unfounded in fact."

In view of the fact that the theories embodied in the letter to Mr. Windom have been most triumphantly sustained by results which followed the construction of the jetties, it is quite possible, that General Humphreys now entertains for Mr. Eads's views a much greater respect than that which is expressed in the above extract.

In answer to an open letter by Major C. W. Howell, who stated that certain necessary conditions for success by jetties did not exist at the mouth of the river, namely—a stable character of banks and a shore current, and that careful engineers had disapproved of the jetty system at the mouth of the Mississippi, and that jetties had once been attempted there and proved a failure, Mr. Eads shows by quoting from

Humphreys and Abbot's Physics and Hydraulics of the Mississippi River, that sufficient velocity of shore current does exist; that the plan of jetties has not really been tried, and that careful engineers have recommended the trial of the jetty system, and refers to the Board of 1852 for confirmation of his statement. He states, that the estimate of General Humphreys for the cost and maintenance of jetties at the mouth of Southwest Pass, for a depth of 27 feet, is double that which he is to be paid, according to his proposition for constructing and maintaining jetties that will produce 28 feet.

He was supported in his views by several distinguished civil engineers, whose opinions are given in his argument.

While Mr. Eads was explaining his views to Congress, every possible interest was brought to bear against him from New Orleans. Its Chamber of Commerce and other commercial bodies passed resolutions favoring the canal plan, and opposing the jetty system.

Their reasons for the canal were, that a long, scientific and patient investigation had convinced a Board of Army Engineers that it was the best and most feasible plan. Their objections to the jetties were, that past experience offered no inducements to hazard the canal by such a doubtful undertaking. The press of New Orleans charged Mr. Eads with being in collusion with the great East and West railroad lines, by continuing the blockade at the mouth of the river, and that all his hopes and fortunes being in the railroad bridge at St. Louis, it was for his personal interest to defeat the Fort St. Philip Canal bill.

The leading business men forwarded an earnest appeal to Mr. Eads to withdraw his proposition, as it would only serve to embarrass and delay the construction of the canal recommended by the Board of U. S. Engineers and the Chamber of Commerce. Their objections to the jetties were, that they

would not stand against the storms, would be readily undermined by the current, would be no protection against the continual extension of the bars, and of no permanent use. The Chamber of Commerce delegated two of its members to proceed to Washington and oppose the jetty proposition. One of these delegates, Prof. C. G. Forshey, a graduate of West Point, was considered to be one of the leading scientists of New Orleans, and had devoted much of his life to the study of the hydraulics of the river and the gulf. The other —Ex-Gov. P. O. Hebert—was also a graduate of West Point, a civil engineer of considerable experience, and had been governor, and afterwards chief engineer of the State of Louisiana. They appeared before the Senate and House Committees, and endeavored to refute Mr. Eads's views expressed in his letter to Senator Windom. Prof. Forshey claimed that they were not practical, not being founded upon the true formation of the delta, and were contrary to what his own life-long experience at the mouth of the river had taught him. Governor Hebert based his opposition to Mr. Eads's views on the results of his personal examination of jetties and deltas in Europe and Egypt.

They subsequently addressed a most earnest appeal to Congress, in which they say: "We have exhausted argument, and laid before you the results of science and experience. We come now with prayer." Referring to the crevasses through the levees and the immense loss which the whole alluvial district had sustained, they state that "every additional inch and half inch of rise in the river counts in the weight of water against our brimful levees. Would you, can you, honorable Senators, at such a moment, contemplate or tolerate the half-insane proposition of strangers, who can know nothing of the habits of our inexorable enemy, to dam up his waters at the mouth by jetties or wing dams, that must inevitably send back the

flood waters like a tide to the very city of New Orleans, or beyond, and complete the impending destruction? Of this result we assure you with an earnestness ground into us by a life-long experience and observation, and by all the lights that science and professional investigation are capable of lending us." * * * "Do not, we pray, permit us to 'be destroyed, and that without remedy.'"

This supplication was signed by these distinguished scientists, as civil engineers representing the New Orleans Chamber of Commerce.

Their labored arguments; their "life-long experience;" their prayerful supplications not availing to stem the tide setting so strongly in favor of the jetties, they counseled earnestly, and at last, at the opportune and critical moment, promulgated and distributed among members of Congress this, their final, conclusive, and crushing argument:

MUD LUMP BLOCKADE
AT MOUTHS OF THE PASSES.

Forty-seven vessels blockaded at Southwest Pass, and one hoisted upon a Mud Lump in the channel that has suddenly reared its head right across the channel.

Major Howell, directing the great Dredges at Pass a l'Outre, replies to the prayer for relief that he cannot respond, because his own Pass is blocked by a vessel on a new Mud Lump in the channel, but in two days he feels confident that he can get her off with his dredges. He is under orders to work away on that pass, in order to keep it open, and the Southwest Pass will have to take care of itself.

For Pity and Economy's sake, if not in the interests of the commerce of the Mississippi Valley, give us the

FORT ST. PHILIP CANAL,

That all Engineers agree and know will be a PERMANENT CHANNEL for deep navigation out of reach of the

INEVITABLE MUD LUMPS

That weekly, daily, and hourly menace the Channels at the mouths of the River.

The LIFTING POWER

Of the Mud Lumps is irresistible, and must destroy any JETTIES or other works of man under which they are liable to rise.

Forty-seven Mud Lumps flanked the Bar of the Southwest Pass on the last Coast Survey.

P. O. HEBERT,
C. G. FORSHEY,
Civil Engineers of Louisiana.

EBBITT HOUSE,
WASHINGTON, D. C., *April* 5, 1874.

By far the most influential and persistent opponent of the jetty system was Gen. A. A. Humphreys, Chief of Engineers, U.S.A.

On April 15, 1874, he addressed a long letter to the Secretary of War, which was transmitted by him to Congress.

The letter was written for the purpose of taking issue with the views expressed by Mr. Eads. He endeavors to show by comparing the soundings of Major Howell, in 1873, with those of Lieutenant Talcott, in 1838, that the gulf is filling up in advance of the bar at Southwest Pass at the rate of two feet per year, and that the "littoral current" which was depended upon by the jetty advocates to sweep away the sediment could not exist. "The prominence which has recently been given to the effects of a littoral current, in connection with the jetty system, is derived entirely from the influence attributed to it in the case of the improvement by jetties of the Sulina branch of the Danube; and because the South Pass is the smallest of the passes of the Mississippi River, it seems to be assumed that the conditions of the Sulina will be found there at the South Pass. * * * The discharge of the Sulina, in high water, is about twenty-four thousand cubic feet per second; in low water about eight thousand cubic feet per second. The South Pass of the Mississippi discharges, in high water, about eighty-three thousand cubic feet per second, and in low water about twenty-five thousand feet per second, and carries to the sea ten times as much earthy matter as the Sulina branch. * * * The small quantity of earthy matter carried to the sea by the Sulina branch, joined to the fact of the existence of a littoral current across its mouth, were the two causes which, in the judgment of Sir Charles Hartley, the engineer of the commission for the improvement of the mouths of the Danube, made the jetty system peculiarly applicable there, and led to its success, the jetties causing the earthy matter in suspension to be

carried out into the littoral current, which then carried of it away." He states further, that the crest of the Si bar remained essentially stationary, so far as any outer m ment is concerned, during twenty-eight years, and that of the characteristics of a delta formation exist at the m of the Sulina; also, that at the mouth of the Mississippi t are two separate and distinct bar formations; the one for by the earthy matter *pushed along the bottom* of the river bar, and the other formed by that part of the earthy m held in suspension; but that in the case of the Sulina br the amount of earthy matter *pushed along the river bed* always very small, and had no controlling power over the formation, and is now carried by the action of the je into comparatively deep water.

It is in his "experimental theory of the formation of b that he finds the most serious objection to the adoptio the jetty system. According to that theory, about one-t of all the sediment carried into the gulf is *pushed alon bed of the river.* When this material, being compose heavier substances, reaches the outer crest of the bars dropped in the "dead angle, or space without curre made by the fresh water rising upon the heavier salt w He makes a calculation, based on this theory, by whic obtains the result that if the jetties contract the channel- over the bar from eleven thousand five hundred feet to width required to produce twenty-seven feet at low w the annual advance of the bar will be not less than tw hundred feet.

Referring to views stated by Mr. Eads, he says: "It been recently stated by a civil engineer, in a pamphlet cerning the improvement of the mouths of the Missis River by jetties, that the amount of sedimentary matter ried in suspension by the Mississippi River is in exact pro tion to the velocity of its current." He quotes at consi

able length from the results of observations made at Carrollton and Columbus, to show that this statement is not correct and is in direct conflict with these results, for they prove "that the greatest velocity does not correspond to the greatest quantity of earthy matter held in suspension; on the contrary, at the time of the greatest velocity of the current at Carrollton, the river held in suspension but little more sediment per cubic foot than when the velocity was least."

He makes a special application of his theories to South Pass, because Major Howell had recently sounded on its bar and seaward of it. From these soundings and his own theories he deduces the result, that the annual advance after jetties are constructed will be six hundred and seventy feet. (See Humphreys and Abbot's Physics and Hydraulics of the Mississippi River, Appendix M, page 667.)

This argument was reviewed by Mr. Eads in a letter dated May 29, 1874, addressed to Hon. S. A. Hurlburt, House of Representatives, Chairman of Committee on Railroads and Canals. An abstract of this letter, with some extracts, is given. He calls attention to the fact, that on April 21st, the day fixed by the House for the consideration of the Jetty bill, copies of General Humphrey's letter were circulated among the members, and says:

"As certain statements in it are based upon unsound theories, calculated to mislead the judgment of Congress, it is proper to correct them. To sustain this theory of bar formation and advance, it is absolutely necessary to establish two facts, which are assumed as the basis of the whole theory: First, that on the outer slope of the bar a 'dead angle, or space without currents,' exists between the river water and the bottom; and second, that the material to form the bar is '*pushed*' along the bottom. Humphreys and Abbot say, on page 482 of their report: 'As a velocity of 0.5 of a foot per second is sufficient to transport the material of which the bar

is formed, the action of gulf currents in carrying into deeper water the material *pushed* by the river into the gulf is evident—' [the italics are mine]." Professor Forshey, having been engaged in current measurements at Southwest Pass, says in Appendix G, of the same report: "We have a velocity *at the bottom* on the bar, full two miles outside of the land, of two feet per second." From observations recorded by Prof. Forshey he finds that at different stages of the river, and in depths varying from twenty-two feet to forty feet on the outer slope of the bar, in this "dead angle" the average velocity was one and three-quarters feet per second, varying from about one foot to three and one-third feet per second, and states that these quotations from Humphrey and Abbot's report disprove the existence of a "space without currents," or a "dead angle," on the outer slope of the bar.

To ascertain the amount of *pushed* material, the means employed are given by Humphreys and Abbot as follows: "A keg similar to that used in collecting water below the surface was sunk to the bottom of the river; the current immediately overturned it, and the valves opening allowed the water to pass freely through. After remaining a few minutes it was drawn suddenly up, and was invariably found to contain material such as gravel, sand, and earthy matter." Mr. Eads says:

"Prof. Forshey has informed us, that no investigations or experiments with a keg, or by any other means, were ever made by Humphreys and Abbot to determine this question, and that the principal hydrometrical data in Humphreys and Abbot's report were supplied by himself.

"To him belongs the honor of discovering, by means of the keg described by Humphreys and Abbot, the enormous amount of material pushed on the bottom, and 'of which the bar is formed;' therefore, upon his investigations mainly rest the fabric of arguments and conclusions respecting the bar advance published by Gens. Humphreys and Newton.

"Frequent examinations of the bottom at ordinary stages of water" (under the diving-bell), "enable me to declare that sand and other sedimentary matters are carried in suspension, and not *pushed* along the bottom. Driftwood, balls of clay, or other aggregations of earthy matter are doubtless rolled or *pushed* along on the bed, and sometimes gravel and boulders, but the amount of these passing New Orleans is very small."

He states that from observations made while sinking the large caissons of the bridge at St. Louis, and from experience on the bed of the river in five or six hundred localities, he knows "that no such material as forms the bars of the passes is *pushed* on the bottom of the river in any such quantity as is requisite to form them, or to serve as a basis for the calculations of bar advance under the influence of jetties, as made by Gens. Humphreys and Newton. Nor is it necessary to create any such special theory of bar formation for the Mississippi River. The bars at its mouth are not formed by any process of nature which differs materially from that at the mouths of the Ganges, the Nile, the Danube, or any other delta river in the world. The bar at the Danube having failed to advance in accordance with the 'dead angle' theory, under the influence of the jetties, it is absolutely necessary to show some remarkable difference between that stream and the Mississippi. Accordingly the statement is made that the Sulina bar is 'derived chiefly from the deposits of *earthy matter held in suspension*, and not *earthy matter pushed along the bottom*.' As the specific gravity of the matter suspended in the Danube is twenty-eight per cent. heavier than that in the Mississippi (according to Gen. Humphreys the specific gravity of the matter in *suspension* in the Danube is 2.5, while that of the Mississippi is 1.96), does it seem reasonable that in the stream in which the sediment is *heaviest* there should be so very little pushed on the bottom, while *enormous quantities*

are pushed along the bed of the stream in which it is the *lightest?* Sir Charles Hartley states, that '*the amount of deposit at the various mouths of the Danube was almost directly in proportion to the volume of water issuing from them.*' We have shown that *by weight* the Danube's suspended matters are greater, and they are stated by Gen. Humphreys to be nearly the same as in the Mississippi *by volume.* From these facts it remains for him to explain how the South Pass, discharging but *one*-third of the volume of the Danube, can carry to sea *two*-thirds as much sediment. The statement made in my letter to Senator Windom, that 'the amount of this matter and the size and weight of the particles which the stream is enabled to hold up and carry forward depends wholly upon the rapidity of the stream, modified, however, by its depth,' is given by Gen. Humphreys as a *verbatim* quotation, but in a *mutilated* form, leaving out the words '*modified, however, by its depth,*' which makes my statement as ridiculous as though I had asserted that the capacity of the river bed is in exact ratio to its width, *without reference to its depth.* Long arguments and extensive tables of velocities of current and quantities of sediment are brought forward to demolish this mutilated proposition, and to refute *what I never asserted.* In reference to my real statement, those who are familiar with the best writers on this subject know that the ability of the stream to suspend its sediment is believed to be *inversely as the depth;* but Humphreys and Abbot, in coming to the conclusion that no relation exists between the velocity and the load suspended, omitted one of the most important elements in the problem, namely, the variations in the *depth* of the stream.

"The whole question really at issue in this matter, is: *Will the required extension of the jetties be twelve hundred feet per annum,* or any lesser rate of importance? Gen. Humphreys answers this question in the affirmative. The views ex-

pressed in Ex. Doc. 220, by Gen. Barnard, and those of Col. W. Milnor Roberts, Gen. J. H. Wilson, Col. Shaler Smith, and Messrs. Chanute, Bayley, Flad, Corthell and others, expressed to me personally, sustain my faith in the negative; for the United States does not contain engineers more able than this list presents. * * * If these eminent engineers, who do not believe such rapid advance of the jetties will be needed, are correct, and the jetties succeed, the nation secures an inestimable prize, *AN OPEN-MOUTH RIVER.* With so much to gain, and so little to lose in accepting my proposition, can it be deemed wise to decline it? If Congress refuses to let me demonstrate the problem at the sole risk of myself and associates, the valley must wait in patience for relief."

Notwithstanding the evident fairness of Mr. Eads's proposition, the influence of the Engineer Corps of the army was so powerfully exerted to prevent the control of the improvement of the mouth of the great river from passing into the hands of "an outsider," as he was called by Messrs. Forshey and Hebert, and the opposition to the proposed jetties was so intense in New Orleans and on the part of the Louisiana delegation in the House of Representatives, that the bill for the construction of the Fort St. Philip Canal was actually passed by a large vote, as a substitute for the Jetty bill, which had been reported favorably to the House by the Committee on Railroads and Canals; the Jetty bill receiving but eighty-nine votes, while the Canal bill, appropriating $8,000,000 to commence the canal with, received one hundred and eighteen votes. The advocates of the canal were of course much elated with this triumph, and at once hurried the bill over to the Senate. Here the question of opening the mouth of the river was in charge of the Select Committee on Transportation Routes to the Seaboard, Hon. William Windom being the chairman.

Before this committee Messrs. Eads, Forshey, and Hebert had been invited to appear about two weeks prior to the passage of the Canal bill in the House. Mr. Eads was required by the committee to open the discussion. He was followed by Prof. Forshey and Gov. Hebert. The fate of the Jetty enterprise, at that most critical moment, hung trembling in the balance, for every effort to defeat it was being made by its influential and vigorous opposers.

It is needless to say that the committee were deeply impressed with the force of Mr. Eads's arguments on that most important occasion, for within forty-eight hours after the Canal bill was referred to this committee, one of its members—Senator J. R. West, of Louisiana—arose in the Senate and stated that he had been authorized to ask that the committee be discharged from the further consideration of the Fort St. Philip Canal bill, and to report, as a substitute for it, a bill authorizing the appointment by the President of a commission of seven engineers, three from the army, three from civil life, and one from the United States Coast Survey, to whom this question as to the proper method of opening the mouth of the river should be referred, with instructions to report at the next session of Congress.

If Mr. Eads had failed before the Senate Committee to refute the arguments of Messrs. Forshey and Hebert, and to convince it of the soundness of his own views, there is no doubt but that the committee, under the great pressure brought to bear upon it, would have reported the Canal bill favorably to the Senate, and in that event it would have been as promptly passed by that body as it had been by the House, and there would have been an end to the attempt to deepen the mouth of the Mississippi by jetties.

Congress passed the bill reported by Senator West, authorizing the appointment of a commission to decide upon the proper method of opening the mouth of the Mississippi. On

this commission the President appointed the following distinguished engineers: Gen. H. G. Wright, U. S. A.; Gen. B. S. Alexander, U. S. A.; Gen. C. B. Comstock, U. S. A.; Prof. Henry Mitchell, United States Coast Survey; T. E. Sickles, C. E.; W. Milnor Roberts, C. E.; and H. D. Whitcomb, C. E.

This commission of engineers in their report made January 14, 1875, say: "The interests involved in the proper improvement of the mouth of the Mississippi are so great, and the work so costly, that it is imperative to obtain the best possible knowledge and judgment as to the method to be adopted. Accordingly, in order that the opinion of the Board should be based on a full knowledge of what has been done, and of the latest results obtained elsewhere in this most difficult branch of engineering, it was decided to visit the mouths of the rivers mentioned" (several of the most important rivers in Europe).

CHAPTER V.

EUROPEAN JETTIES.

A SUMMARY of the construction of jetties in Europe, a the results obtained by them, will be of interest, as bear upon the question of the adoption of that system at mouth of the Mississippi.

The Dvina is a river with many of the characteristics the Mississippi, although much smaller. It is a sedime bearing river of Russia, discharging into the Gulf of Ri a tideless arm of the Baltic. The depth on the bar v increased by jetties from six feet to eighteen feet, and th has been no advance of the bar, although the jetties believed to have been built more than one hundred ye ago: how much earlier is not known, as there are no reco in the Department of Public Works at St. Petersburg t extend back to the date of their construction.

A chart of the mouth of the Oder (a river of Prussia, d charging into the Baltic), bearing date of 1776, shows je lines, some of which, near the land, are marked 1756. T depth was increased from seven feet to twenty-four feet.

One of the most important constructions for the benefit commerce, at the mouth of a small river, is the artific channel at the mouth of the Maas, in Holland, by which port of Rotterdam is furnished an outlet to the sea. canal was cut through the "Hook of Holland," and jett were constructed at the sea end, extending into deep wat

The River Scheur, a branch of the Maas, was then closed by a dam, and its waters turned into the new channel. The jetties were built of willow fascines, combined into mattresses, and were sunken and loaded with stone. They project into the sea upon a sand shore to a depth of twenty-seven feet, and were the first constructions of that kind on the open sea-shore. They have successfully withstood severe storms and most violent wave force undisturbed.

The failure of the dykes at the mouth of the Rhone to give a permanent and deep channel, has been used as an argument against the jetty system at the mouth of sediment-bearing rivers. The Rhone discharges into the Mediterranean Sea through four passes—the main pass, flowing in the general direction of the river, carrying about one-half its volume; the other three passes may be considered lateral outlets.

Dykes for the improvement of the bar at the principal mouth were commenced in 1852. The plan consisted in the closing of the three lateral outlets by a continuous dyke, extending from the mainland above the point where they commence to diverge, and extending to the mouth of the principal outlet. Another dyke, or levee, was built on the opposite bank, to prevent the escape of the water through the small bayous and over the lowlands. These dykes terminated nearly one mile inside the crest of the bar. They are partly earthen dykes, and partly of stone. The width of the channel at the sea end of the dykes is thirteen hundred and twelve feet. The width of the Rhone at the head of the delta is six hundred feet.

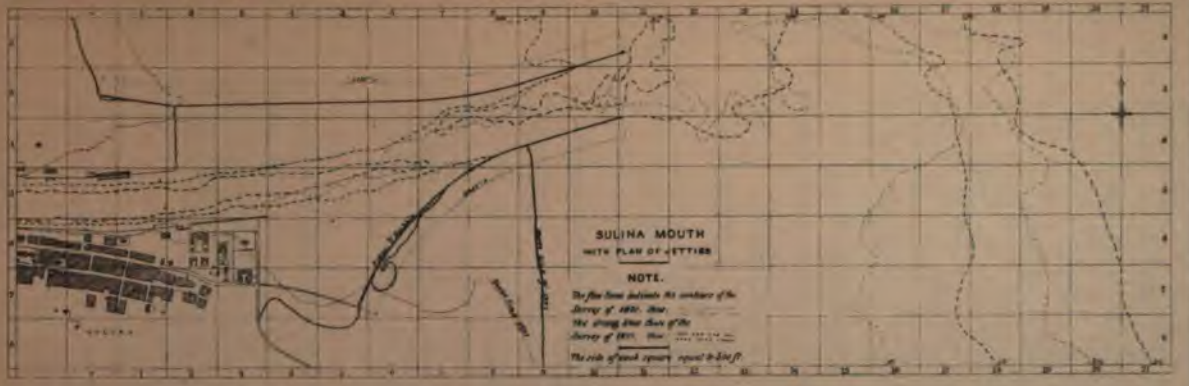
Under the influence of the dykes, which were finished in 1856, the depth increased from five feet to thirteen and a half feet; but then the bar moved seaward, and the depth had diminished in 1863 to four and a half feet. The attempt to maintain the channel by dykes was abandoned. A

landed interest, desirous of building a maritime city a fe miles above the mouth of the river, exerted a sufficient in fluence to have a ship canal constructed, which was com menced in 1863. It started at the point opposite the he of the upper lateral outlet, and extended to the Bay of F It is two and a half miles in length; has a depth of ninete and a half feet; required seven years of labor to compl it, and cost three million dollars.

The closure of the lateral outlets, by which the volu issuing from the main pass was doubled, also doubled t amount of sedimentary matter discharged upon the b The process of bar formation at the mouth of the Miss sippi teaches us that the distance of the crest of the b from the land's end is determined by the volume issu from each pass. Consequently, if the volume of the Rh issuing at its principal mouth be doubled, the crest of t bar would at once assume a new location, more distant fr the land's end than before; and as the dykes were not b out to within a mile of the crest of the bar they could h no influence in checking its advance, nor in permane increasing the depth upon it. It is absurd to quote Rhone as an illustration of the jetty system. Where t system has been successful, the works have invariably b extended out beyond the crest of the bar into the de water.

The River Danube, its delta, its regimen in respect to currents and sedimentary matters, the formation of its ba and the characteristics of the sea into which it discharg are similar in many respects to the Mississippi River. F this reason the jetties constructed at the mouth of one of branches, and the results obtained by them, need to be scribed more fully than those of any other river, in ord that lessons may be drawn from them that will apply to t solution of the problem at the mouth of the Mississippi.

PLATE 5.









The following facts are taken from two papers read before the Institution of Civil Engineers of Great Britain by Sir Charles A. Hartley, Chief Engineer of the European Commission of the Danube—one read in 1862 and the other in 1873. This commission was constituted in 1856, by virtue of the Treaty of Paris. It consisted of delegates from the seven contracting powers—Austria, England, France, Prussia, Russia, Sardinia, and Turkey—and it was charged to execute the works necessary to clear the mouths of the Danube and the neighboring parts of the sea from the sands and other impediments which obstructed them.

The Danube, after a course of seventeen hundred miles, receiving more than four hundred tributaries, and draining upwards of three hundred thousand square miles of country, passes the Bulgarian town of Isaktcha in a single channel seventeen hundred feet wide and fifty feet deep. This city is seventy-six miles from the sea by the Kilia branch, seventy-eight miles by the Sulina branch, and ninety miles by the St. George branch. The general character of the delta can be understood best by an examination of Plate No. 5.

The Sulina abstracts one-fifth of the waters of the Toulcha branch, or two twenty-sevenths of the whole volume of the main river. Its navigable width is rarely more than three hundred feet. During high floods the inclination of the surface of the Sulina is three inches per mile. In ordinary high water the velocity of the current in the main river is between two and one-half and three miles per hour. At times of extraordinary floods the velocity is increased to five miles per hour, and the whole volume of water then delivered by the Danube to the sea is equal to sixty million cubic feet per minute. When the waters are most surcharged with sediment, they bear to the sea as much sedimentary matter as would be equivalent to a deposit of one cubic inch to one cubic foot of water. During high river the bars at the mouths of the

passes are farther from the shore, their magnitude increased, and the depths over them diminished. The process is as follows: The current, with its earthy matter, by its quickened speed deepens the channel over the bar, the displaced portion is pushed out into the shallows beyond, and there the river current, checked by the nearly stationary waters of the sea, precipitates the heavier particles of the matter in suspension to form a new bar, while the lighter particles are carried further and widely distributed over the sea depths beyond. There are no tides in the Black Sea, into which the Danube discharges, and the level of the water along the delta is solely influenced by the opposing action of the land and sea winds.

The Sulina branch having been selected for improvement, piers were projected across the bar to terminate in a depth of eighteen feet, in order, in the first instance, that the proposed channel might be deepened by the concentrated action of the river current, and that afterward a good navigable channel might be maintained between the piers; it being assumed that, when the troubled waters of the river were brought into immediate contact with the littoral current crossing the pier heads, the fluvial matter would remain suspended until it was far removed from the entrance. The piers were built of piles, cribwork, and a protecting slope of rubble stone. The works at first were provisional. They were commenced in 1858 and finished in 1861. The depth on the bar, before the construction of the works, varied from seven to eleven feet, and was rarely more than nine feet. In 1862 there was a navigable channel of seventeen and one-half feet. In 1866 the commission concluded to convert the piers into solid structures. This consolidation was completed in 1871. The provisional works near the pier heads had been beaten down by the waves, so that they were three or four feet below the surface of the water. The new works were constructed of concrete blocks.

In 1872 an effective depth of twenty feet was secured, and that depth has been maintained until the present time, with often a depth of twenty-one and one-half feet. The effect of these works upon the growth of the bar into the sea has been to retard it, for, considering the twenty-four feet and thirty feet contours, the average extension for ten years, ending in 1871, was only forty-four feet per annum, whereas during the eight years immediately previous to the beginning of the works the same contour lines advanced at the rate of ninety-seven feet per annum. The reason for this retardation is, that at present the silt-bearing waters of the river issue at once into deep water beyond the pier heads, and are carried far to the southeast by the littoral current, instead of flowing into the sea, as formerly, with a feeble and constantly decreasing current, by numerous shallow channels.

In a letter dated November 30th, 1874, addressed to G. W. R. Bayley, an eminent civil engineer, and an early and earnest advocate of the jetty system, and afterward associated with Mr. Eads in the construction of the jetties as Resident Engineer, Sir Charles Hartley compares the Danube and the Mississippi. He presents the points of resemblance and difference, and from them obtains the most cogent reasons for constructing jetties at the mouth of the latter. He is in favor of South Pass in preference to the larger passes, on the score of economy in construction and maintenance, and his comparisons are mostly drawn between the South Pass and the Sulina branch.

The first objection against the construction of jetties at the mouth of the Mississippi, namely, the soft and silty nature of its bars, is readily disposed of; for the South Pass bar is described in the report of Assistant G. G. Meade, in 1839, as being principally composed of fine gray sand, mixed with a very small proportion of mud; and in Major Howell's last survey the bank to the east of the bar is described as

being of hard sand. This description fits precisely the Sulina bar, before it was removed by the scour of the river, and as jetties were constructed across it without difficulty or great expense, there is no reason why the same advantages should not attend the construction of jetties at South Pass. The second objection urged against the jetty system is, that the waters of the Mississippi being charged with more sedimentary matter than the waters of the Danube, the injurious effects of precipitation are more to be feared at the former. He shows by lengthy and exhaustive argument,

First. That the waters of the Danube transport a greater number of heavy particles of matter to the sea, in proportion to the whole weight of sediment, than the Mississippi, and,

Second. Granting that the statement is correct that the Mississippi, while discharging only three times as much water, really discharges six times as much deposit in weight, the annual advance of the Mississippi mouths "two hundred and seven feet annually, according to the latest surveys," is nearly at the same rate as that of the Danube mouths. This apparent phenomenon is simply due to the far greater depths of the sea off the Mississippi delta, an advantage which fully compensates for the threefold greater volume of the river, and the greater amount of sedimentary matter. The sea slope of the bar of the South Pass is one in sixty-six; that of the Sulina one in two hundred and sixty-four. He meets the third objection, namely, that there are no littoral currents off the Mississippi mouths, by proving that such currents do exist. All testimony confirms that the prevailing winds off the Mississippi delta are from the northeast and southeast. The resultant of these winds is east, which may therefore be called the prevailing wind.

He points out that a glance at the map of the alluvial region of the Mississippi shows, that whilst the general

trend of the river from New Orleans to the head of the passes is in a southeast direction, the deposit is nearly all to the west, or in the direction of the current produced by the prevailing winds; in the same way that the Danube deposits take place to the south, under the influence of the prevailing winds from the north-northeast. The same observation applies to the *set* of the deposits below the head of the passes, the growth of the delta in a west and southwest direction being three times greater than in the opposite direction.

After stating facts, which we have given in a previous chapter, in regard to observations for shore currents, he says: "The reasons above given for my full faith in the existence and efficacy of the littoral and tidal currents justify me, I think, in saying that the salient position in the gulf of the southwest and south mouths of the Mississippi—exposed as they are to the full action of these currents and beat of the waves—is evidently very greatly in favor of their successful treatment by means of jetties, and that the rapidly increasing depths beyond their bars give them—as far as their improvement is concerned, by the same method—a very marked superiority over the Danube mouths. If at the Sulina mouth the inclination of the sea bottom had been as steep as off the South or Southwest Passes of the Mississippi, a depth of twenty-eight feet might as easily have been obtained there, at a slight additional cost indeed, but with the great advantage that the silt-bearing waters would have been carried much farther seaward, owing to the increased depth of the channel, and into such depths that the formation of a shoal, such as now forms after a high flood, within one-half mile of the pier heads, would have been impossible for many years to come. * * *

"My conviction is, that by increasing the erosive powers of the current, relatively to the depositing action, the piers

will have the effect not of accelerating the growth of the accretions of the sea bottom, but of greatly retarding it. * * * Practically, therefore, I consider that the element of bar advance may be discarded from the minds of the present generation."

Without giving further descriptions and details of the jettied mouths of the rivers of Europe, the following table will serve to show the extent to which the jetty system has been adopted there, and the success which has attended it.

Name of River.	Country.	Original Depth, Feet.	Present Depth, Feet.
Danube	Roumania (Turkey)	7 to 11	20
Maas	Holland	00	18
Vistula	Prussia	7	10
Trave	Prussia	7	18
Oder	Prussia	7	24
Warne	Prussia	6	13
Persante	Prussia	4	15
Wipper	Prussia	4	13
Prezel	Prussia	12	20
Stolpe	Prussia	4	14
Niemen	Prussia	10	24
Siban	Russia	6	16
Dvina	Russia	6	18
Windova	Russia	4	9
Pernean	Russia	6	12
Nissa	Sweden	5	12
Koune	Sweden	6	10
Altra	Sweden	6	9
Grenaa	Denmark	5	13

From the preceding résumé of jetty construction we can see that, for a great many years, all along the shores of the Black Sea, the North Sea, and the Baltic, Russia, Prussia, Holland, Sweden, Denmark, and Turkey have built and maintained jetties. The record of their works teaches us plainly that, whether the bars were caused by the waves of the sea

or the waters of the rivers, whether they were "drift" or "delta" bars, the piers, dykes, and jetties, when pushed out into the deep water, have in every instance not only produced the depth needed, but have maintained it permanently against wave action and sedimentary deposits.

CHAPTER VI.

REPORT OF THE BOARD—PASSAGE OF THE ACT AUTHORIZING THE CONSTRUCTION OF JETTIES AT SOUTH PASS.

In the interval between the adjournment of Congress in July, and its reassembling in December, 1874, a remarkable change in public sentiment had taken place.

When Mr. Eads returned from Europe, where he had spent several months in carefully examining and studying the jetty system at the mouths of several important European rivers, and in consulting with the distinguished engineers who had constructed them, he found the country and Congress ready for a favorable consideration of his plans. The leading journals, especially in New York and in nearly every city of the Mississippi Valley, advocated the views which he had so clearly expressed in and out of Congress.

The report of the Board of Engineers was presented to Congress on January 13, 1875, by the Secretary of War. The following is an abstract of the report, the full text of which is given in Appendix 2. In reference to a canal, they show the advantages and disadvantages of several locations, and decide in favor of a site near Fort St. Philip, and give an estimate of the same, which for cost of construction and maintenance is $11,514,200.

As to the deepening of a natural outlet, they are of the opinion that no admissible expenditure of money can permanently maintain by the stirring process a depth of twenty

feet, and that this depth is not adequate to the wants of commerce. In reference to jetties, they first give the facts on which their application at the mouths of the Mississippi is based.

The fact of principal importance is, that as the bars move out to sea, the river is all the time eroding a channel of the characteristic deep water cross-section behind and through them. The object of jetties is to aid and hasten this erosion. The plan recommended by the Board is to begin parallel dykes at the banks of the pass, where there is now thirty feet of water in the middle, and carry them over the bar to thirty feet of water outside. The river will erode the bottom between the dykes till the water-way everywhere has the same cross-section as at their beginning. The depth of thirty feet is chosen in order that some time may elapse before the bar, which will form at the sea end, can have less than twenty-five feet on it, that being the minimum depth which it is desired to maintain.

In selecting the pass to be improved, they give the preference to South Pass; for, while its width is only seven hundred feet, as against fourteen hundred feet at Southwest Pass, the former, when improved, will be adequate to the present and prospective wants of commerce. The estimate for construction and maintenance of jetties at the mouth of South Pass is $7,942,110, and for Southwest Pass, $16,053,124.

They are satisfied from their examinations abroad that the jetties should be constructed of brush fascines and stone, in the same general way as those at the mouth of the Maas, in Holland. They discuss the question of the advance of the bar after the jetties are completed, and give their opinion, that in one hundred and twenty years the crest of the new bar will probably be found twelve thousand feet beyond its present location, and for this reason they estimate for the cost of the average annual extension that will be necessary, $130,000.

In comparing a ship canal and jetties they recommend the latter, and their application to South Pass. They say: "It would give a good sea entrance about nine hundred feet wide, and a minimum width in the pass of about five hundred and thirty feet, while the width of the canal would be about three hundred feet. It would offer no locks (liable to do or suffer injury) to delay the passage of vessels through it. It would give an ample unobstructed waterway to commerce, in place of a narrow and obstructed one." The Board concludes its report with a recommendation that if Congress decides to open one of the passes of the river, the entire sum necessary to accomplish the work be appropriated at once or in some way be made available; for the work, when once begun, should be pushed as rapidly as possible to its entire completion. This report was signed by all the members of the Board except Gen. Wright, who stated that, in his judgment, the chances of success of an attempted improvement of any one of the natural outlets of the river did not justify the recommendation of the Board; but he conceded that if an adequate and permanent channel *could* be obtained at any one of the passes, it would no doubt be preferable to the proposed canal. Soon after the report of the Board, Mr. Eads made a new proposition to Congress, to make a channel thirty feet deep at the mouth of Southwest Pass for $8,000,000, and maintain it for twenty years for an annual sum of $150,000; the first payment of $500,000 to be made when a channel of twenty-two feet in depth and two hundred feet in width was obtained, and $500,000 more when this depth was maintained for a year; then $1,000,000 each year for the addition of two feet permanent depth to the channel until thirty feet was reached; the remainder to be retained by the Government, one-half for ten years and the other half for twenty years, as a guaranty for the performance of the work.

A bill embodying this proposition was introduced in the

House of Representatives about the 8th of February, 1875. Like the bill introduced in the previous session, it met the determined opposition of the Chief of Engineers, U. S. A., who at once presented his views to Congress through reports to the Secretary of War.

In New Orleans the sentiment of the community had changed considerably. Many of those who had strongly opposed the jetties, when they now saw that Mr. Eads's proposition was virtually indorsed by the Commission of Engineers, used their influence to secure the adoption of Southwest Pass, as proposed by Mr. Eads, instead of the South Pass, as recommended by the Commission.

Mr. Eads's objections to the South Pass were—

First. That an extensive shoal existed at the head of that Pass, which it would be difficult to remove, and that the channel obtained through it would be difficult of navigation; and,

Second. That the channel through the pass was too small for easy navigation, and inadequate to the growing wants of commerce. Mr. Eads, learning that the Board was likely to adjourn without inviting him to appear before it, although its creation was the result of his action, addressed a letter to its president, in which he expressed the determination to press the adoption of the jetty system, regardless of the decision of the Commission, and suggested the propriety of its hearing what he had to say upon the subject before making their report. In reply he was promptly invited to state his views before the Commission. He addressed it for two and a half hours upon the subject, during which time he laid before it the facts which he had obtained by his personal inspection of the jetties at the mouths of the Oder, Wipper, Persante, Vistula, Pregel, Danube, and the Rhone, and in conclusion urged the Commission, in the following forcible language, to recommend the improvement of the Southwest

Pass: "It is rarely that gentlemen of our profession have such an opportunity of so indelibly recording their judgment. I earnestly trust that you will, on this occasion, unanimously recommend the improvement of the Southwest Pass, and thus leave, as an imperishable evidence of your foresight and public spirit, such a deep and broad channel at the mouth of the grandest physical feature of this continent, as shall win for you the thanks and praise of the hundreds of millions which the Mississippi Valley will hereafter contain, and whose grand commerce must naturally and forever seek that route to the sea."

The House Committee on Commerce, to whom the bill was referred, examined all its features thoroughly, heard all explanations, listened patiently to all arguments, *pro* and *con*, and studied carefully the wording of the bill, that a contract so important might be drawn up with correctness and precision; and, notwithstanding the fact that the Commission had recommended the improvement of the South Pass, it adopted Mr. Eads's recommendation to improve the Southwest Pass, and reported the bill to the House unanimously. On February 18, ten days after the introduction of the bill into the House, it was made the special order of the day. Ex-Gov. Stanard, of Missouri, made an able speech, full of facts and arguments, in favor of the measure. He explained its provisions, showed what it proposed to accomplish, and demonstrated that the sums to be paid under it were several million dollars less than the estimates of the Army Engineers for a canal, and less than that of the Commission for jetties, and that the interests of the government and the public were guarded with the utmost care, in respect to the payments for the work. An able speech was also made by Hon. O. D. Conger, of Michigan, and the bill then passed, with but two dissenting voices. When it reached the Senate it was amended by the committee there, and made to apply to the

small pass, in spite of all the arguments Mr. Eads could use to prevent it. The reason for this was, that Congress had obtained the advice of one Commission of Engineers, who had recommended the Fort St. Philip Canal, and it had then asked the advice of a subsequent one, which had recommended jetties at the little pass. If it refused the advice of both these councils of experts, and voted to place the jetties at the great pass, and they failed to accomplish what Mr. Eads claimed they would, Congress would then have no defense for having refused the advice of its own experts in the matter. Besides this reason, which, to say the least for it, was founded in an unwillingness on the part of the members of the Senate Committee to take the responsibility of deciding between experts (Mr. Eads being one, as well as the Commission), there was the more weighty reason of its costing two and three-quarter million dollars less to improve the little pass. The Senate Committee were immovable in this decision, and Mr. Eads was informed, that if he would give the same guaranties, and agree to produce the same depth of channel with the little pass that he had guaranteed for the big one, and build the works for five million two hundred and fifty thousand dollars (which was much less than the Commission's estimate), and guarantee its maintenance for twenty years for thirty thousand dollars per annum less than the Commission's estimate for that item, the improvement should be confided to him; otherwise it would be placed under the control of the Corps of U. S. Engineers, who had fought him at every step, and whose acting chief had predicted the failure of the jetty system, if ever tried at the mouth of the Mississippi.

Thus modified, the bill was reported to the Senate and passed.

The concurrence of the House in the Senate amendments was secured just before the final adjournment of Congress on

the 3d of March, 1875, and on receiving the President's signature the bill became a law.

As this law authorized the construction of the work, it is given entire and verbatim in Appendix 3.

On the 24th of March, 1875, at a banquet in St. Louis, given to Mr. Eads in honor of this great victory, at which there were three or four hundred of the representative men of that city, and many distinguished gentlemen from all parts of the Mississippi Valley, in a speech, earnest and eloquent, he explained the secret of that implicit faith which he had in his proposed plans, and which moved him to undertake the great work. He said: "If the profession of an engineer were not based upon exact science, I might tremble for the result, in view of the immensity of the interests which are dependent on my success. But every atom that moves onward in the river, from the moment it leaves its home amid the crystal springs or mountain snows, throughout the fifteen hundred leagues of its devious pathway, until it is finally lost in the vast waters of the gulf, is controlled by laws as fixed and certain as those which direct the majestic march of the heavenly spheres. Every phenomenon and apparent eccentricity of the river—its scouring and depositing action, its caving banks, the formation of the bars at its mouth, the effect of the waves and tides of the sea upon its currents and deposits—is controlled by laws as immutable as the Creator, and the engineer needs only to be assured that he does not ignore the existence of any of these laws, to feel positively certain of the result he aims at. I therefore undertake the work with a faith based upon the ever-constant ordinances of God himself; and so certain as He will spare my life and faculties, I will give to the Mississippi River, through His Grace and by the application of His laws, a deep, open, safe, and permanent outlet to the sea."

Several gentlemen of considerable means were interested

with Mr. Eads when the concession was granted by Congress. With such means as they were willing to embark in the enterprise, added to his own, it was evident that there would still be needed a large sum of money to execute that portion of the works required to insure a depth of twenty feet, at which period only could government payments be expected. It is proper to state that the estimates of the Commission of 1874 contemplated the construction of mattress work, as it was executed at the Maas, in Holland. By the provision in the act which left Mr. Eads "untrammeled in the design, location, and execution of the work," he was free to exercise his ingenuity to discover some cheaper and equally effective method of construction. In this he foresaw the opportunity of so cheapening it as to leave a large margin of profit at the price stipulated in the act.

The first step taken by him in solving the financial problem was to execute a contract with the substantial contracting firm of James Andrews & Co., by which that company agreed to furnish, at their own cost, the necessary plant, steamers, barges, boarding-houses, etc., and place in position fifty thousand cubic yards of mattress work, and ten thousand cubic yards of stone, before demanding of Mr. Eads any payment whatever. After this amount of work should be executed, one-half the agreed price for it was to be paid in cash, and the remainder when certain payments should be received by Mr. Eads from the United States. The prices agreed to be paid were so high that the contract was limited to three hundred and fifty thousand cubic yards of mattress work and the attainment of twenty-six feet of water. We see thus far two distinct parties interested—

First.—Mr. Eads and his associates, who controlled the concession, and

Second.—The contractors who undertook to construct a certain portion of the jetties.

It was necessary to provide for such additional funds should be required beyond the personal abilities of the two parties. Hence a third company was formed, called t South Pass Jetty Company, which was in reality a limite partner with Mr. Eads and his associates, from whom it w to receive one hundred per centum profit on such sums as should be required from time to time to advance to Mr. Ead and ten per cent. interest on the sums so advanced until the were repaid. The payment of interest, principal, and prof were solely dependent on the success of the enterprise, an were secured to the company by assignments from Mr. Ead of certain parts of the different payments set forth in the ac of concession. This company was strictly a financial one, an had no control or voice in the direction of the work.

By the contract between Mr. Eads and the South Pa Jetty Company, the amount of its advances was limited $200,000. This amount was subsequently increased to abo $500,000, owing mainly to the difficulties thrown in the w of the enterprise by official hostility. The continued do of success, which was sustained in the public mind throu the unreasonable hostility which during the first two or th years continued to hamper the work, compelled Mr. Eads raise such additional amounts of money as were required, most exorbitant rates of interest.

CHAPTER VII.

SOUTH PASS—LOCATION OF JETTIES—CONSTRUCTION.

He who lives among the highlands will find it difficult, from any verbal description, to form in his mind a true picture of the lowlands of the Mississippi delta. But to him who dwells among these marshes, descriptions of an upland country come like restored pictures, bringing again the scenes of the past. In imagination he stands on some lofty summit, and beholds the range of mountains losing itself in the blue hazy distance; the shaded river meandering down the valley; the fields of wheat and corn, that climb yon slopes to the very summit; the pine-covered hills, clad in perennial green; the everlasting rocks, throwing out their jutting crags against the sky, and the villages dotting the landscape here and there, diversifying it with their picturesque beauty. From this imaginative picture he turns with reluctance to look upon his present surroundings. With the exception of the lighthouse, there was, in June, 1875, no elevation within one hundred miles, nor any building, except a few fishermen's huts, within ten miles of the mouth of South Pass. A view from the top of the South Pass Lighthouse takes in the whole country; a low, flat marsh of mud, reeds, and grasses, which, in long narrow strips, is thrust out into the gulf. Except a solitary mud-lump, about two miles away, near an outlying reef, there is not a spot as far as the eye can reach that is not overflowed by the river or the tides. There is

not even a background of high land to relieve the monotony of the scene; but away to the eastward, just distinguished, are the low, willow-fringed banks of Pass à Loutre, like a dim pencil line drawn between the blue waters of Garden Island Bay and the azure sky above. To the westward is another dim horizon line, marking the course of Southwest Pass. Around the whole half of the circle, from the northeast to the southwest, there is nothing to be seen but the broad expanse of the Gulf of Mexico.

From the lighthouse, extending ten miles to the northwest, in easy, graceful curves, we can follow South Pass through the yellow marsh, "a silver thread in a cloth of gold;" and with a glass we can distinguish, nearly hid among the willows, the lighthouse at the Head of the Passes. Halfway up on the west side of the pass, detected by the scattered clumps of trees along its banks, is Grand Bayou.

The South Pass is a beautiful, natural ship canal. There is not a shoal, nor a sharp turn, nor a dangerous bank, nor a snag even, in its whole length. In the presence of the great river, or of even the two larger passes, it is only a bayou; but in Europe or on the continent, it would be classed as a river of considerable magnitude. The pass flows over a bed and between banks formed of its own deposits. In cutting its way through them it has shaped its channel to the exact requirements of the volume and velocity of its waters. The annual overflows deposit their coarser matters on the immediate banks, and the finer sediment farther away; for this reason the ground next the pass is about one foot higher than that some distance from it. On the higher banks is a dense growth of reeds, ten or twelve feet high, forming a strip next the pass, about one hundred feet wide. A coarse marsh grass grows in the lower ground. The width of the land lying between the pass and the bays, in some places, is not over one hundred yards, in others fully half a mile. With

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the exception of the higher ground next the pass, the whole marsh is composed of a material so soft that it is difficult to walk upon it, and a pole can be forced down into it with the hand to a depth of five or ten feet. A few willow trees on the right bank below Grand Bayou, and a few near the head of the pass, constitute the only growth larger than the reeds throughout its length.

In June, 1875, the only marks of civilization beyond the land's end at the mouth of the pass were a small white flag here, a temporary platform there, a stake driven into a drift-log imbedded in the mud, a tall tripod erected on a mud-lump, or an instrument-stand on a reef; these told us that the U. S. Coast Survey had just preceded us, and that each shore and bar, each reef and contour line, each elevation and depression in the pass, or in the gulf beyond it, had been carefully surveyed and mapped out by those who for skill and accuracy have a wide reputation. By a provision of the jetty act, the Superintendent of the U. S. Coast Survey was instructed to make "as soon as practicable, a careful topographic and hydrographic survey of the pass and bar." The surveying party, Assistant H. L. Marindin in charge, arrived at the mouth of South Pass with the survey schooner *Research*, in April, 1875. Although delayed by fogs and rough weather, he accomplished his work in the allotted time, and presented Mr. Eads, on his arrival in May, with not only a complete map of the mouth of the South Pass, but of the pass itself, Grand Bayou and the Head of the Passes. The results of his surveys at the mouth of the pass are shown on Plate A. The plane of reference was mean low water, as ascertained from daily readings, on a staff gauge at the lighthouse, taken during the period covered by the survey. This plane was 1.8 feet below that of average flood tide —the datum plane—subsequently established by the U. S. Engineers. The soundings have been changed on the chart to

agree with the latter plane of reference. The charac soundings only are given, with the most important cc The shore lines, and all elevations above average flo are bounded by full lines. The chart shows that the g depth along the whole length of the bar was 9.2 fee mean low water 7.5 feet. At flood river the navigabl was about eight feet at average flood tide. It also sho a plateau, nearly level and about three thousand feet i extended from the outer crest of the bar, back towa land's end. On the very crest or shoalest part, nea deep water of the gulf, the material was a fine sand which the waves and currents had washed all the clay ter, and disposed it in a narrow ridge, about a foot than the remainder of the plateau. Immediately sea the bar-crest was a softer material. This outlying sl very uneven, composed of hills and hollows arrange what uniformly in lines parallel with the outer face of

These features, and other interesting facts connect the geology of the bar, will be discussed in a sub chapter.

Mr. Eads studied this chart, and laid out the lines jetties upon it. He was accompanied at the time of to South Pass by Mr. James Andrews, who, with his ates, had contracted to construct the works, and wh diately commenced the execution of his contract, fo he was eminently fitted, by a long and successful ex on public works—railroads, tunnels, bridges, especi foundations of the St. Louis Bridge and the large tun nected with it, extending under the city.

Mr. Andrews possessed those peculiar qualities de of the contractor by a hazardous and difficult enterpr by a work requiring great rapidity in construction, re of financial hindrances and of losses and delays ca the destructive forces of the gulf waves and river c

He brought to the work the qualities that had made him so successful elsewhere, and had won for him the respect and admiration of all who knew him—great energy and persistence, an invincible will, a quiet determination, and an unswerving confidence in the success of the enterprise.

The considerations which determined the location of the jetties were,

First.—To place them at such a distance apart as would make them secure against any subsidence of the ground on which they were to rest, that might be induced by the excavation of a deep channel near them.

Second.—To direct the discharge into the sea across the littoral current, and not against it.

Third.—To inclose the natural channel within the jetties, and thus leave the shoalest water on each side of it, in which to construct the jetties, and thus lessen their cost. In determining the width of the jetty channel, Mr. Eads intended from the first to close Grand Bayou, and, consequently, he would have to control as much water as there was in the pass above Grand Bayou. The average width of this part of the pass is seven hundred feet, with an average depth of over thirty feet. Mr. Eads believed that a greater area of cross-section would ultimately be attained between the jetties, especially near the sea end, than that which the current of the river alone could maintain in the pass, owing to the erosive action of the tides, and that it would not be safe, for this reason, to place the jetties nearer than one thousand feet from each other.

With respect to the second consideration, it is an observed fact, that delta-forming rivers, when they enter the sea, have a tendency to direct their currents against the littoral currents of the sea, for the reason, that the suspended sediment which they discharge is carried by the sea to the leeward bank of the river, and the accretions, which are made upon

this bank from the river discharge, cause it to grow more rapidly than the other, and finally to curve the fluvial current around against the littoral current. For this reason the direction of the discharge from the South Pass, and the direction of the pass itself, is from northwest to southeast, while the prevailing littoral current is from the east.

No doubt the direction of the main river, from northwest to southeast for the lowest one hundred miles of its course, has been determined by the tendency of the prevailing winds and the littoral current of the gulf to increase the sediment embankment upon its western shore, and thus give the current of the river a tendency to oppose the littoral current of the gulf. To direct the current from the pass completely at right angles with the littoral current, would have been very desirable, but it would have involved too great a curvature in the alignment of the jetties, and the curve which is thrown into this alignment may be said to be a compromise between the desire to make the current of the river cross the littoral current at right angles, and the fear of causing the deepest part of the channel between the jetties to follow the concave side of the jetty channel too closely, and thus endanger the stability of the east jetty, in the part where the curve exists.

The following from the daily journal of Mr. Bayley, the Resident Engineer, will serve to introduce the narrative of the construction work.

"*June 12th.*—James Andrews started from New Orleans about one o'clock A.M., with a steam tug, towing a floating steam pile-driver and three flat-boats, one of which was fitted up as a boarding boat, and the other two were loaded with materials for three framed houses, to be erected at Port Eads, for quarters, warehouse, and offices, and with other materials for the works. On the same day, the stern-wheel steamboat

Grafton arrived at New Orleans from St. Louis, with a barge loaded with coal and machinery.

"*June* 13*th*.—Three mooring piles were driven in the edge of the pass, and several for the foundation of the houses. The steamboat *Grafton*, with coal barge and machinery, arrived at Port Eads to-day.

"*June* 14*th* to 16*th*.—Piles were driven for a wharf at 'East Point,' at the land's end, on the east side.

"*June* 17*th*.—Work on the east jetty was commenced, by driving piles from the land's end in the direction of the 'wreck' (shown on the chart)."

The east jetty extended twelve hundred feet from the land's end, in the direction of the "wreck." It then deflected to the right or westward one foot in twenty-three feet, in a straight line, for a distance of two thousand eight hundred feet; then one foot in sixteen feet, for four thousand one hundred feet. At this point (eight thousand one hundred feet from "East Point"), a curve commenced, still deflecting to the westward, with a radius of eleven thousand seven hundred and twenty feet, in chords of six hundred feet. This curve, with the six hundred feet chords, was extended to a point eleven thousand seven hundred feet from the land's end. It was then continued with the same radius a distance of four hundred feet, making the total length of the east jetty twelve thousand one hundred feet, or nearly two and one-third miles. This alignment was established by a line of piling, the first mile of which consisted of two rows, twelve feet apart, the piles in each row being eight feet apart. Over the remainder of the jetty line only one row was driven, and the distances between the piles varied from ten to twenty feet. With the exception of those in the first mile, where it was intended to use sheet piling, the piles were simply guides for sinking the willow mattresses, which constituted by far the largest and most important part of the

jetties. As the "mattress" was a novel and peculiar plan for using willows in sea-walls and dykes, a description and sketch of it is given.

About forty-five years ago the river broke through its west bank, twelve miles above the head of the passes, at a narrow fisherman's canal that led up to it from the gulf. In a short time a torrent eighteen hundred feet wide and sixty feet deep swept through this crevasse. For a long time the river at flood poured through it with great velocity, and spread its muddy waters far and wide over the shallow bay. The same principles that produced a delta at the mouth of the river formed one here. After the lapse of years there appeared well-marked channels, three or four feet deeper than the adjoining shoals, which gradually rose to the surface by he deposits of successive overflows. These shoals confined the currents still more to the channels, and increased their depth. The seeds of grasses, flags and reeds that came down with the river found a lodgment on the half-submerged banks, and soon covered them with a rank vegetation. This growth caught the sediment carried into it by the overflowing waters and built up the banks still higher, on which sprang up a dense growth of willows, crowding out the weaker vegetation and taking possession of the whole district. A richer and more conveniently arranged harvest-field for the jetties than this great tract of willows could not have been found. This crevasse is generally known as the "Jump." The passes of the Jump were sufficiently wide and deep to admit a good-sized steamboat, and they ramified this sub-delta in every direction.

The willows grow six or eight feet in height every year, and the more frequently they are cut the denser is the growth. The willows used in the mattresses were from fifteen to thirty feet in length, and from one inch to two and one-half inches in diameter at the butt. The trees of two or

three years' growth are straight and free from branches, and much better adapted for the mattress work than the crooked limbs of the larger trees. The willows were cut and loaded on barges. The steamboat *Grafton* took the empty barges into the Jump, placed them where needed, and brought them out when loaded. These barges were from one hundred and twenty-five feet to two hundred and twenty-five feet in length.

The men who cut the willows, in order to be near their work, lived in boarding-boats, that were moved from one place to another. The task they had was not an enviable one, as the ground, or rather mud, was overflowed by high river and high tides, and it was necessary to carry the willows in bundles sometimes four hundred or five hundred feet, the men sinking at every step into the soft mud. The willows were piled up compactly ten or twelve feet high on the deck of the barges, the butts in the middle and the tops overhanging the sides. When properly loaded, the large barges carried from four hundred to six hundred cords. They were towed to Port Eads and placed alongside the mattress ways on which the mattresses were built. The ways are shown in plan and elevation on Plate 6, the mattress on Plate 7.

Piled up near the ways were strips or scantling, of yellow pine, six inches wide, two and one-half inches thick, and from twenty feet to forty feet in length. They were placed on small trucks, and run on the platform to the place where the mattress was to be constructed; they were lifted upon the ways and placed side by side, as many as were necessary for the width of the mattress; if forty feet wide, nine strips were used, spaced five feet apart from center to center. The mattresses were usually one hundred feet in length. To make that length, the strips were connected by a lap joint, the lap being the same size as the strip—about six feet long—and fas-

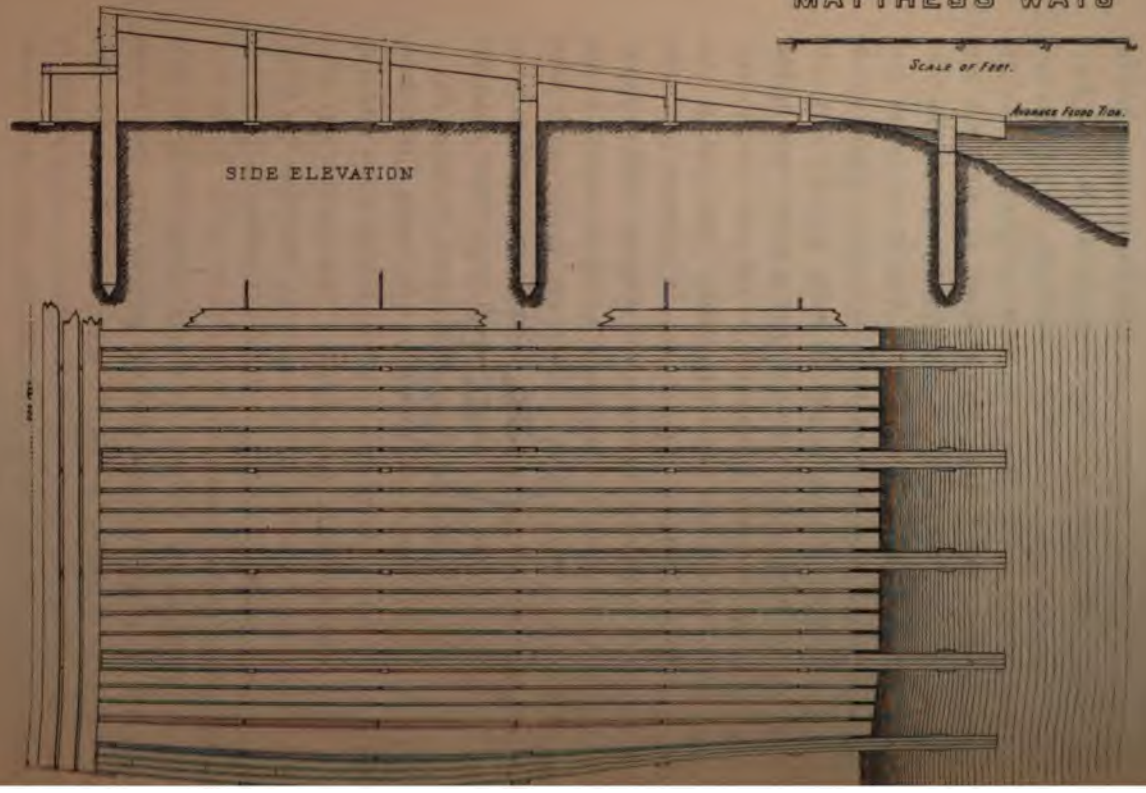
tened to the main strip with five-inch spikes. Wh work was finished, one and one-eighth inch holes, fi apart, were bored through each strip. Round hicko or stakes, about two feet long between shoulders, w ends turned to fit these holes tightly, were driven t the strips. The ends of the pins were cut off flush w bottom of the strip, and oak wedges about three long were driven into them, and twenty-penny nai toenailed through the strip. The strips were then down the ways, the lowest one being placed near and with the water's edge. They were spaced with a four and one-half feet apart in the clear, and held i temporarily by an inch board tacked across them.

The willows were then passed from the barge mattress gang, who placed them in the bays betw rows of pins and at right angles to the strips, the tops overhanging the frame about three feet. Wl whole surface of the mattress was raised about tw of its height, another layer was laid at right angles first, and brought up two or three inches higher tl tops of the pins. Strips, the same size as those in t tom frame, were placed across the mattress for bin which holes were bored to receive the tops of th and the binders were forced down on them by mauls and levers. The pins were held in place by and nails, as in the bottom strips. To strength mattress, longitudinal strips were fastened to the near the edge of the mattress. When the mattress be exposed to heavy seas, iron screw-bolts were use corners in place of hickory pins.

Previous to filling the mattress, a bridle line of ro inches in diameter, with an eye in the center, was a as follows: The running ends were drawn under th to near the upper corner, and fastened temporarily tc

PLATE 6.

MATTRESS WAYS




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the pins with spun-yarn. The eye of the bridle was outside of the frame next to the water, and that also was lashed to a pin, so that it could be reached easily, when the mattress was ready for launching. Two head lines, one and one-quarter inches in diameter, and about seventy-five feet long, were fastened in the end of the frame in the same manner, a trip line three-quarters of an inch in diameter being spliced into the end of the head lines.

When the mattress was finished, the running ends of the bridle were made fast to a piece of mattress strip, about six feet long, placed across two binders. Similar toggles were run through the eyes of the head lines, and their running ends coiled up on the mattress, which was then ready to be launched. The steam tug came alongside and made fast to the eye of the bridle, and moving out into the pass launched the mattress, which was towed, either alongside or astern, to near its intended position along the jetty piling. The position of the sea end of the mattress previously sunken had been carefully noted, and the upper end of the new mattress was brought to that point. The yawl crew ran out with long lines, tied to the head lines, and made them fast to the guide piles, some distance above the location of the mattress. The tug then "let go," and the mattress was swung by the current to its place along the guide piling. A stone-barge was then placed against the river edge of the floating mattress, and the rubble rock or riprap was carried out and spread evenly over it, until it was nearly sunken beneath the surface. The rock was then thrown upon the edge next the barge, which was swung by the force of the current over the sinking mattress, the rock in the meantime being thrown upon it rapidly. When the mattress was sunken, the long lines that held it to the piles were let go, and underrun, to where they were made fast to the head lines; the bow-line was untied, and the head lines drawn up through the mat-

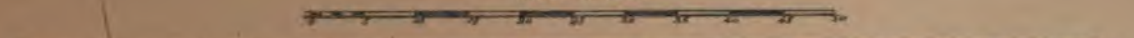
tress by the trip lines, which had previously been made fast to the piles above the surface of the water.

With slight variation in manner of construction, handling, and sinking, this plan was followed throughout the whole work.

The plan of these mattresses was the joint invention of Mr. Eads and Col. Andrews, and was patented by them. With the strips, pins, and willows, ready at the ways, it was possible to make and launch a mattress one hundred feet long, thirty-five feet wide, and two feet thick, in two hours. By the Dutch system the same size of mattress would probably require at least two days for its manufacture.

MATTRESS

SCALE OF FEET.





SECTION THROUGH AA



SECTION THROUGH BB





SECTION THROUGH CC

PLATE 7.


RARY

CHAPTER VIII.

CONSTRUCTION—DESCRIPTION AND PROGRESS OF WORKS AT THE MOUTH OF SOUTH PASS, FROM JUNE, 1875, TO JUNE, 1876.

THE economy of the jetty system at the mouths of sediment-bearing rivers is largely dependent upon the rapidity with which the works are constructed. The re-formation of the bar seaward of them is probably hastened, and in some instances produced by a dilatory construction, and these evils are prevented by their prompt completion.

This and other important reasons demanded rapid construction at the mouth of South Pass. By the provisions of the act the government made no returns to Mr. Eads for his large outlays until he had secured the prescribed channels. Again, as the payment for the first channel of twenty feet depth would cover only a small part of the expenses incurred in obtaining it, it was necessary that the greater channels, in fact the maximum channel, should be obtained as quickly as possible. For these reasons strenuous exertions were made to push the work forward, both in raising the necessary capital and in supplying the materials and plant for the work. The verbal and written instructions of Mr. Eads to his assistants dwelt constantly on the necessity for rapid construction.

As he and Mr. Andrews were both unavoidably absent during the summer and early fall, the general direction of affairs was given to Mr. Bayley, who was stationed at New Orleans, that

he might be able to attend promptly to the finances and supplies.

The details of the construction work were, under the supervision of Mr. Bayley, intrusted to E. L. Corthell, the Chief Assistant Engineer, who was instructed to do all that in his judgment was considered necessary to hasten the work for securing the twenty-feet channel at the earliest possible moment. As this result depended in a great measure upon the facilities for building mattresses, the construction of mattress ways was hurried forward, and in one month from the sinking of the first mattress, five hundred lineal feet of ways were completed, and on the 15th of September, eight hundred lineal feet were ready—three hundred and fifty feet on the east side of the pass and four hundred and fifty feet on the west side.

The reeds were cut down on each side of the pass for a width of seventy-five feet from the banks, for store-room for piles, mattress strips, lumber of various kinds, stone, coal, etc., and the necessary shops, houses, wharves, and walks were built. The banks, which early in June were uninhabited and desolate, were now alive with men engaged in their various vocations, and resounded to the sound of axe and anvil, pile-driving, and the whistling and puffing of the tugs and steamboats.

The experience of the engineer in charge, gathered from his letter-book and journal, will show with what urgency both the preparatory and construction work were pressed, and will excuse the absence, in the record of that period, of any scientific observations which may have been expected of him by his professional brothers.

Being unfortunately without assistants for some time, he was superintendent of the works, engineer in charge, transitman, draughtsman, chainman, recorder, and calculator. His daily work consisted in measuring and checking, by instru-

mental angles from two stations a mile or more apart, the location of the guide piling of the east jetty, which was being rapidly extended out to sea by two pile-drivers; calculating the distances for the back ranges by which each chord of six hundred feet was driven; establishing the right angle for them with a pocket sextant; making surveys to ascertain the effect of the mattresses upon the channel, and taking soundings along the line of the piles each day, and over the whole length of the piling at least once a week. It often happened that, while superintending the surveys and at the same time measuring the angles with a transit set up on "East Point" wharf, he was obliged to read and answer important dispatches relating to the progress of the work, and reply to questions from New Orleans about the character and quantity of material needed, and at the same time direct several gangs that were building mattresses, ways, houses, wharves, flats, walks, etc., or, in other words, superintending the numerous constructions carried on by a force of three hundred men. It was a satisfaction to ascertain later, by the measurements of the United States inspecting officer, that the sea end of the guide piling, established under such difficulties two and one-third miles from the land's end, was correctly located within the possible error of one foot.

Throughout the summer the work was greatly delayed by inability to procure good laborers, and by the failure of the contractor to furnish willows in sufficient quantities for the work. These various difficulties were, however, more than counterbalanced by having experienced and capable foremen; by a rigid enforcement of total abstinence from intoxicating liquors; by prompt payment of laborers and bills for supplies, and, by direct communication by telegraph with New Orleans. These were the personal conditions that affected the progress of the work. In the meantime the construction was going forward as rapidly as the circumstances would al-

low. A description of each work and results accomplished during the year will be given briefly.

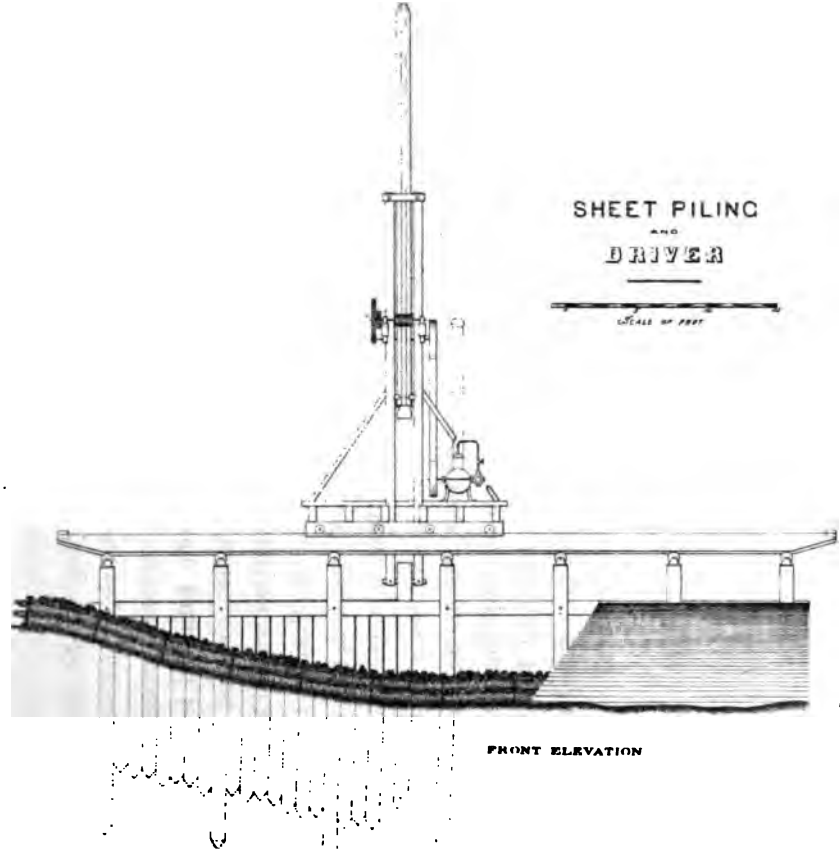
On September 9th the guide piling of the east jetty was finished, its terminus being twelve thousand one hundred feet from the land's end. For convenience the distances were noted like the stations of one hundred feet used in railroad construction. The initial point, or zero, for all distances and measurements on both jetties was "East Point;" thus the end of the east jetty was at Station 121. Every fifth guide pile was numbered and marked, and its distance noted. The location of the mattresses was plotted on the profile by knowing their position in reference to those piles.

The foundation mattresses were laid in advance of other work; they were from thirty-five to fifty feet wide, two feet thick, and from seventy-five to one hundred feet long. This formed a continuous carpeting, which prevented any deepening of the bottom in advance of the work as it progressed seaward.

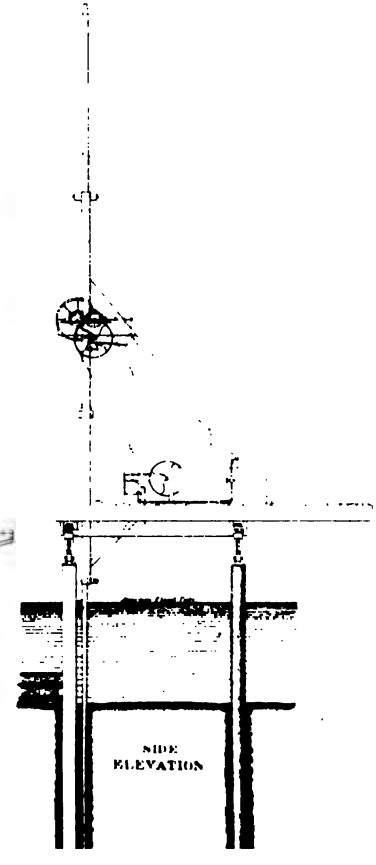
In order to hasten forward the construction of the east jetty, near the sea end, the first mile was constructed of sheet piling, after the base had been protected by a mattress carpeting. The sheet piles were driven by two traveling drivers, moving forward on the two rows of piles previously spoken of, which were cut off to an uniform height about two and one-half feet above average flood tide. One of these drivers was arranged like an ordinary pile-driver, the hammer weighing about twelve hundred pounds, and running between guides or leaders. It was raised by a line running through a sheave in the head block of the leaders, and thence to the drum of the engine. In the second driver the hammer was raised by friction gearing. It was composed of an iron head weighing three hundred and fifty pounds, with a wooden stem about twenty-four feet long attached to it, and made of three pieces of oak, the whole weighing about

PLATE 8.

SHEET PILING AND DRIVER



FRONT ELEVATION



SIDE ELEVATION


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twelve hundred pounds. In order to raise the hammer, two iron friction rollers were forced against the stem by a lever worked by a steam cylinder; the rollers were then revolved by a pulley from the engine. When the hammer was raised to the required height, the pressure on the lever was removed by exhausting the steam in the cylinder; the rollers separated about one-quarter of an inch, and the hammer thus freed dropped upon the pile. The machinery was geared to give a quick motion to the rollers, and the blows were given in rapid succession. The details of the construction of the driver, with a section of the sheet piling, are shown on Plate 8.

The sheet piles were of yellow pine, from twelve to fourteen inches wide, five inches thick at the upper end and three inches at the lower end. They were from fifteen to twenty-five feet in length. A waling timber (6″ by 12″) was fastened with screw-bolts to the sea side of the river row of large piles, so that its upper surface was two inches above the datum plane. The sheet piles were driven close together, edge to edge, and as near as possible to the top of the waling timber, and were then fastened to it with eleven-inch drift bolts. The average depth driven was twelve feet; depth of water nine feet; fall of hammer fourteen feet; number of blows fifteen; number of piles driven per day by the ordinary driver, sixty-eight; by the friction driver, seventy-seven. On one day, in seven and a half hours' work, one hundred and seventy-six piles were driven by the friction driver. The sheet piling was commenced the last of August, and completed in October, extending to Station 52 + 80.

When the river rose in the winter, it brought a head of water against the piling on the river side, which at ebb tide often amounted to four inches. As the foundation was sand, it was very soon affected by the current, which forced its way through the small openings between the piles, and made deep

holes under them, in several places washing out the sheet piles, and in two places both rows of guide piles.

In order to stop this undermining of the work, mattresses eight feet wide and three and one-half feet thick were built on skids hung from the tops of the two rows of piles, and lowered to the bottom between them. Fourteen hundred lineal feet were protected in this manner. The mattresses beyond the sheet piling in the line of the jetty were laid on on the river side of the guide piling. As each course was narrower than the one immediately underneath—the course at the surface of the water being twenty or twenty-five feet wide—a slope was formed on the river side. This plan was adopted for the sake of economy, expecting that the deposit on the sea side of the jetties would protect them from wave action.

On the 30th of November two courses of mattresses were laid to Station 115; in February, 1876, to Station 119, and in March the whole jetty, with the exception of the first mile, where sheet piling had been driven, was raised to the surface of the water. Reference is made to cross-sections of the east jetty, shown on Plate 9, for widths and thickness of the various courses. Previous to construction the least depth of water on the line of the east jetty was six feet, the greatest depth thirty feet, and the mean depth eight feet.

The guide piling of the west jetty was commenced September 21st, at Station 40 + 58, six hundred and fifty-one feet from "Kipp" Signal Station, and one thousand feet from the east jetty guide piling, and was extended seaward parallel with it. Foundation mattresses, thirty-five feet wide and two feet thick, were laid on both sides of the piles to Station 83. At this point the work was suspended to await the decision of the Advisory Board of Engineers, which had assembled by request of Mr. Eads, and to whom he submitted his plans for the location and construction of the works, with the view of

SECTION OF JETTIES.

BETWEEN EAST POINT AND 6500 RESP. 9000 FEET SEAWARD

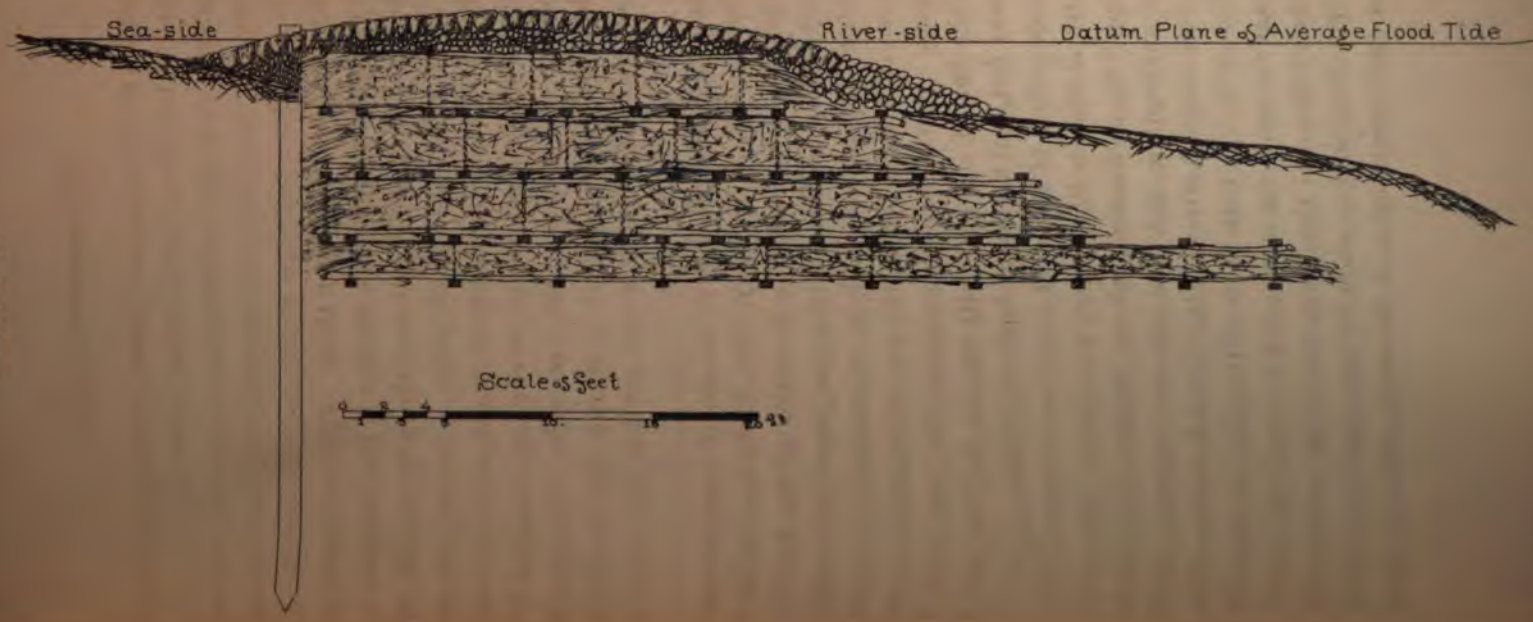


PLATE 9.


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guarding against the possibility of error. They advised a radius of fifteen thousand feet for the west jetty curve, its terminal point at the sea end to be one thousand feet from the east jetty, and the beginning of the curve to be at Station 69 + 15. (See Appendix 4 for full proceedings of the Board.)

The piles driven beyond this point were cut off even with the surface of the mattresses; the new line was commenced at the point named, and carried, with its designated radius, over the crest of the bar to its terminal point at Station 117 + 60, the distances between the piles varying from sixteen to twenty-nine feet. Messrs. Eads and Andrews returned to Port Eads about the last of October. The force was largely increased, and the work was pushed forward through the fall and winter with still greater energy.

"Kipp Dam," or the work connecting the west jetty with the shore line at "Kipp" Signal Station, was finished first. The length of this dam is five hundred and fifty feet.

The depth of water increased gradually from the shore line to eighteen feet at the west jetty. A row of piles eight feet apart was driven, and a waling-strake of 6″ × 12″ timber was bolted to them. Foundation mattresses sixty feet wide and two feet thick were sunk above them. On the first course wooden aprons sixty feet in length were placed in a vertical position, rising two feet above the datum plane. These aprons were sections of wooden dams constructed and sunk as follows: The ways, on which they were constructed, were built like mattress ways, but of lighter material, the timbers being 4″ × 4″ scantling, placed five feet apart, and extending back from the river about twenty-five feet. Two battens were first laid down on the ways at right angles to them, the distance between these battens corresponding to the width of the apron. Three-inch plank laid close together were then spiked across these battens, the tops being even and the lower ends

uneven, to conform to the irregular shape of the mattresses on which they were to rest. Two battens were then spiked to the upper surface of the planks, immediately over and lengthwise with those placed underneath. The apron was then launched from the ways by the tug, and towed to its place along the dam. The pile-driver then raised it into a vertical position, the force of the current pressing it closely against the guide piling. It was then forced down to the mattresses by means of levers and the pile-driver hammer. Piles were then driven on the upstream side of the apron and bolted to the guide piles, thus pinning the apron in its place. A timber was then bolted across above the apron to prevent its rising at flood tide by its buoyancy or by the lifting power of the waves. A second course of mattresses, thirty-two feet wide and two feet thick, was then laid horizontally on the upstream side of the aprons and against them. The aprons along the whole length of the dam were put in place in one day—November 28th, 1875.

Although the river was very low, yet this sudden obstruction to the current produced a head of water above the dam which at ebb tide was between seven and eight inches. This forced a strong current through the opening between the lower edge of the aprons and the mattresses, which excavated deep holes below the dam, where no protecting mattresses had been laid—at one place increasing the depth from ten feet to thirty feet, and producing an average deepening along the whole line of the dam of from eight to ten feet. Although this deepening did not extend more than sixty feet beyond the dam, yet it was sufficient to undermine the lower edge of the mattresses, and at one point to wash out the piles for a space of fifty feet—carrying the apron through the opening. The piles along the whole length of the dam were undermined, and the work was in danger of being swept away.

A second row of piles was driven eight feet apart and ten

feet above the old row. An attempt to build another temporary structure against this row of piling was made, but soon abandoned, as the force of the current broke it down. The dam was then built to the surface as quickly as possible, with mattresses laid horizontally, after which the deep holes that had been excavated behind the dam slowly filled up with deposits of sediment.

Immediately after placing the aprons along Kipp dam, the same kind of work was placed along the west jetty, connecting with the aprons of the dam, and extending seaward three thousand and forty feet. The aprons varied in height from six to fourteen feet, according to the depth of the water, and rested on the second course of mattresses.

It was fortunate for the stability of the jetty that mattresses had been laid previously along the whole length of this apron work, on the sea side of the guide piles; but even with this ample protection, the head of water forced the current under the apron with such a velocity as to produce an overfall at the western edge of the mattresses, and a partial undermining of them. Had these mattresses not been laid, there is no doubt all this work would have been undermined and destroyed.

A severe storm, which occurred on December 22d, broke up several of the aprons, after which a third course of mattresses was laid as soon as possible along the whole length of this work, effectually securing it. The uniform width of the foundation mattresses of the west jetty was thirty-five feet, and extended to the sea end of the guide piling.

The succeeding courses were narrower, being reduced to a width of twenty-five feet at the surface. Before construction the greatest depth of water on the line of the jetty was eighteen feet; the least depth seven and a half feet; and the mean depth twelve feet. The whole jetty was raised to the surface of low water about April 1st, 1876.

From April to July 1st, the time was occupied in building up the low places on the jetties; in reinforcing the river side of the sheet piling with a course of mattresses; in placing stone on the exposed portions of the works, and especially in constructing wing-dams or spurs at right angles to the jetties. The immediate object of this latter work was to hasten the development of the channel, by contracting the water-way from about nine hundred and fifty feet to seven hundred feet. There were several localities in the channel where the material was a tough clay, holding out obstinately against the eroding force of the current.

A contraction near the sea ends of the jetties was especially needed, for there the volume of water was much less than in the channel above, on account of the cumulative amount of leakage through and over the jetties, as the sea end was approached. From this cause thirty-five or forty per cent. of the volume of water passing "East Point" escaped before reaching the gulf.

Between the first of May and the last of June, eight wing-dams were built, or in all about twelve hundred lineal feet. They were located in pairs from Station 90 to Station 118; those on the west jetty being opposite to the corresponding dams on the east jetty.

The method of construction was as follows: A line of guide piles was driven out from the jetty about one hundred and fifty feet towards the channel. Foundation mattresses were sunk above these piles, connecting with the jetty mattresses, and extending fifty feet beyond the end of the proposed dam; a second row of piles was driven through them, twelve feet from the lower edge and eight feet apart, and a waling-strake was bolted to the lower side of the piles two feet above the datum plane. The mattresses for the dams were seventy-five feet long and from one to two feet thick, one edge being straight and the other irregular or sloping, to

conform to the depth of water on the foundation mattress. The mattresses having been towed to near their places above the dam, were lifted up by a steam pile-driver, which raised the lower edge sufficiently to allow the current to strike against the side of the mattresses, forcing them to their places in a vertical position against the piles, where they were held in a manner similar to the wooden aprons previously described.

These dams did not stop the current completely, but checked it only. They were intended to be temporary structures, and to meet an immediate want. They accomplished their object effectually, and proved to be important aids in the final development of the channel.

The concurrent results of the works constructed during the first year, at the mouth of the pass, will be given in the following chapter; the estimate of the cost of construction of the mattress work is given in Appendix 5.

CHAPTER IX.

ADVISORY BOARD—RESULTS OF WORKS—FINANCIAL EMBARRASSMENTS—GOVERNMENT ENGINEERS.

THE location and plans for the construction of the jetties and other works, determined upon by Mr. Eads, were approved by the Advisory Board of Engineers, which met first at New York, September 2d, and at Port Eads November 18th, 1875. This board was composed of experienced and distinguished engineers—Gen. J. G. Barnard, U. S. A.; Gen. B. S. Alexander, U. S. A.; Sir Charles A. Hartley; W. Milnor Roberts, C. E.; T. E. Sickles, C. E.; Prof. Henry Mitchell, United States Coast Survey, and H. D. Whitcomb, C. E. On the motion of Sir Charles Hartley, Gen. Barnard was chosen President. They decided upon the alignment of the jetties, and approved of the mattress construction, which, they say, "is essentially the same as that applied to the jetties at the mouth of the Oder, and also to the jetties at the mouth of the Maas, so successfully as to draw from the lower legislative body of Holland the announcement that 'their complete success has removed all doubts as to the possibility of making piers at sea on our coast.'"

The Board made a careful examination of the works begun, and of the location of other works, and, after advising in reference to them, gave its general opinion in regard to the prospects of their ultimate success. In reference to South Pass

itself, they believed that it would furnish an open mouth of ample depth for the largest class of sea-going vessels.

They had previously satisfied themselves that the opinions expressed by many, that the local peculiarities of the South Pass bar—its extreme softness, eruptive mud-lumps, etc.—would thwart efforts to lay upon it substantial and permanent engineering constructions, were unfounded, and they say: "It is satisfactory to be able to state positively, after four months of actual operations, that the work of pile-driving, extending from the east land's end to twenty-six feet depth beyond the bar crest, * * * and an examination of the texture of the bar and of the shoals on which the works are to rest, furnish the most satisfactory evidence of a bottom material not only adequate to bear all the necessary works, but even to suggest that but for motives of economy, the jetties, as at the Sulina mouth of the Danube, might be made wholly of stone." They stated that the difficulties were much less than those attending the construction of several recent successful works of the kind, on European shores, examined by the members of the Commission. They considered the delta of the Mississippi and the Danube similar in many important respects, but the mouth of the South Pass of the Mississippi, owing to the greater sea depths beyond the crest of its bar, *more* susceptible of improvement than was the Sulina mouth of the Danube. They entertained no doubt as to the efficiency and permanency of the jetties when they should have been completed upon the location and plans heretofore approved by them. (See Appendix 4 for full report of the Board.)

At the end of the first year's work the jetties were simply walls of uncompressed willows, but even in this unfinished and unconsolidated condition they effected very important results. This principle was from the beginning forcibly illustrated, that with a bed composed of a material that will yield readily

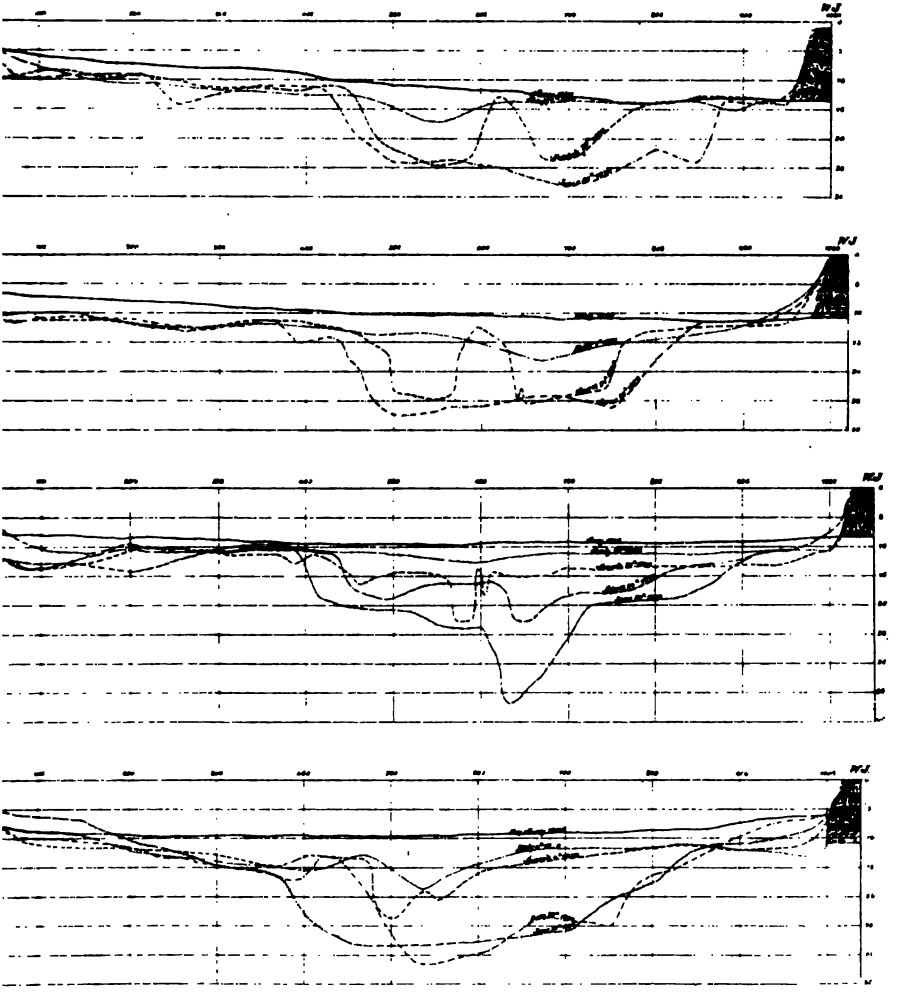
to the abrading power of the current, any obstruction, however small, will cause a corresponding deepening somewhere in its vicinity.

The first intimation that such a result had occurred here, was the deepening noticed in the channel near the foundation mattresses very soon after they were sunken.

After the construction of Kipp dam and the aprons of the west jetty, a deepening of two or three feet took place in the channel near these works, although the river was at that time at a very low stage, the result being due almost entirely to the outflow of the ebb tide. The river rose in January, 1876, and the floods that had hitherto found a wide mouth through which to discharge their waters now struggled to reach the sea through a contracted outlet. Finding the bar like a dam in the channel, they attacked it with great force, the first result of which was that wherever there were deposits of sand a rapid and decided deepening occurred. Over the whole two and one-third miles from the land's end to the gulf, a most irregular channel appeared, full of ridges, mounds, deep excavations, and suddenly appearing and disappearing shoals and channels, but after a time comparative uniformity in section and regularity in the course of the channel took the place of these variable conditions.

Cross sections of the channel at various points, shown on Plate 10, and the profile of the bar, on Plate 11, will more clearly illustrate the channel development. For a more detailed study of the subject, tables in Appendices 6 and 7 are referred to, which show the progressive changes in the channel in the line of the greatest depth, and the gradual disappearance of the bar by the removal of interruptions to the contour lines of various depths. The improvement of the channel, for the benefit of navigation, can be clearly seen from the following table, which shows the draught of water which could be taken through each two thousand feet of the

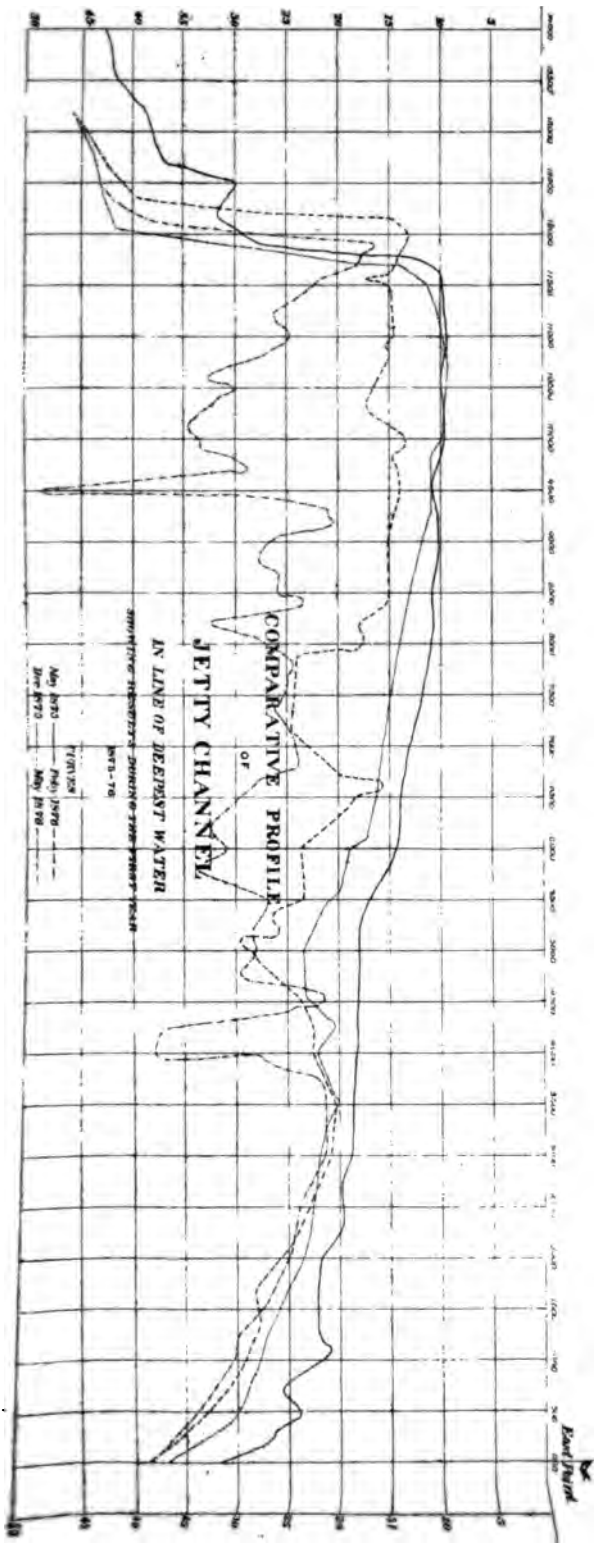
PLATE 10.



CROSS SECTIONS
OF
JETTY CHANNEL
SHOWING RESULTS DURING FIRST YEAR
1875-76


THE ASTOR LIBRARY
NY

PLATE II.


COMPARATIVE PROFILE
OF
JETTY CHANNEL
IN LINE OF DEEPEST WATER
SHOWING RESULTS DURING THE FIRST YEAR
1875-76
FIGURES
May 1875 ——
Dec 1875 - - - -
May 1876 ——
Band Point


LIBRARY

ıannel below East Point Station, in June, 1875, and in May, 876 :

	Distances in feet.					
	0–2,000 feet.	2,000–4,000 feet.	4,000–6,000 feet.	6,000–8,000 feet.	8,000–10,000 feet.	10,000–12,100 feet.
Draught, 1875..	22.5	18.7	16.7	10.2	9.7	9.2
Draught, 1876..	23.3	20.3	22.0	22.1	24.1	16.9

The total amount of material scoured out of the bar by the current and carried into the gulf in one year was 1,711,200 cubic yards. Deducting from this quantity the amount of shoaling at various points near the jetties, we have 1,519,812 cubic yards, which is the amount to be considered in the channel development.

The principle stated in a preceding chapter, that when jetties are commenced at the mouths of sediment-bearing rivers it is important to hasten them to completion, is forcibly illustrated by the effect upon the bar of the partial contraction of the waterway during the summer and fall of 1875, especially upon the crest of the bar ; for in October the depth over it had diminished from 9.2 feet to 7.5 feet.

During the development of the channel extensive deposits of sediment occurred on the sea side of both jetties. As early as August, 1875, examinations showed that deposits were being made both on and behind the mattresses of the east jetty, and the land was rapidly forming and extending some distance seaward of the jetty piling. Gen. C. B. Comstock, United States Engineers, who had been appointed by the Secretary of War, as inspecting officer for the government, in his report of June 9th, 1876, stated that extensive shoaling had taken place on the outside of the west jetty, and from a table of depths given we find that over the first 2,000 feet the

depth of shoaling was 8.1 feet, over the second 2,000 feet, 11 feet, over the third 2,000 feet, 8 feet, and over the fourth 2,000 feet, 5.5 feet.

The channel had deepened so rapidly during the months of January and February, 1876, that Mr. Eads was desirous of celebrating the 4th of March—the anniversary of the passage of the jetty act—by sending the first sea-going vessel through the jetties. He arranged for the three-masted schooner *Mattie Atwood*, bound for Revel, Russia, to go to sea through South Pass, on that day. She was loaded with two thousand one hundred and fifty bales of cotton, and her draught was thirteen feet six inches. On account of a delay at the head of the passes the tide had fallen several inches before she reached the jetties, and the channel at this time being very irregular and changeable, the pilot was unable to keep the vessel in the deepest water, and grounded her opposite Station 80. The tide falling, she remained on the bar during the night, but went to sea at noon the following day.

A little later in the work an incident occurred, apparently insignificant, but fraught with important results, which seriously embarrassed the whole enterprise. To appreciate it, one should have been connected with the jetties during those discouraging days, which, while they brought an improved channel, were gloomy with forebodings of financial disaster; to still better appreciate it, one should have been in the place of Mr. Eads, on whose shoulders rested the heavy burden and the responsibility of the success of the undertaking.

Many of the friends of the enterprise in St. Louis, desirous of seeing the work and forming their opinions of its results from their own observations, arranged for an excursion to the jetties on the steamer *Grand Republic*. They were joined at New Orleans by many others also interested in the work. Among the excursionists were several representatives of the press both of New Orleans and St. Louis.

The *Grand Republic* left New Orleans for Port Eads on the morning of April 26th. Interested in such a distinguished arrival, we watched for the great steamer with deep interest. But what is that dark speck, moving so quickly toward us from the head of the passes; now passing Port Eads, rushing seaward till almost lost to sight on the bar near the ends of the jetties; now galloping across the channel like a race horse; now zigzagging here and there in its desultory course like a swallow skimming over the waters; now coming up again through the jetties; tying up at the lighthouse wharf, and for an hour lying motionless and quiet as death? It is the steam launch of Major Howell, United States Engineers, in whose little cabin his assistant, with nervous haste, with note book and protractor, is plotting the soundings just taken, so as to have them ready for the arrival of the *Grand Republic*. He has left his legitimate work at the mouth of South-west Pass, and has hurried here, a distance of thirty miles, to find facts (?) to controvert the statements made by Mr. Eads and his engineers, that there is a channel of sixteen feet through the jetties.

In the mean time the *Grand Republic*, with its host of friends arrived. After passing through the jetties and into the Gulf of Mexico, she returned to the wharf at Port Eads. By this time Major Howell's assistant had completed his work; had made a tracing of his chart; had placed it in his pocket, and was ready to be interviewed. He took a conspicuous stand in the saloon of the *Grand Republic*, and very reluctantly (?) from time to time drew out the chart for inspection by reporters and others.

It was a good opportunity for this faithful henchman to show his fealty, and he used it to good purpose. Although the act performed by the assistant of Major Howell was insignificant and unimportant in itself, it was the cause of a spirited controversy, and resulted in a remonstrance to the

Secretary of War, and the issuance of orders by him which carried with them a severe rebuke to Major Howell and his superior, the Chief of Engineers, by completely interdicting them from any further official interference whatever with Mr Eads and his work.

In order to refute anonymous statements circulated in New Orleans, and published in a number of journals throughout the country, to the effect that a new shoal was forming in advance of the jetties, and that their failure was therefore certain, Mr. Eads had, on March 7th, some time previous to this occurrence, addressed a letter to Hon. C. P. Patterson, Superintendent United States Coast Survey, Washington, D. C., requesting that instructions be given Assistant Marindin, who was then at the jetties, to survey the outer slope of the bar. The instructions were given on condition that Mr. Eads would furnish a steamboat for the survey. Marindin was engaged in this survey at the time the *Grand Republic* visited the jetties.

The apparently reliable and official statements of the assistant of Major Howell created great distrust in the ultimate success of the jetties in the minds of the friends of the enterprise, who were on the *Grand Republic*, and many of the jetty stockholders in the city of New Orleans, in consequence of which a large amount of stock subscribed in aid of the undertaking was actually offered for sale soon after at half its face value. Realizing the importance of promptly refuting by official testimony, the misrepresentations that had been made, Mr. Eads addressed another letter to Mr. Patterson requesting that Marindin take soundings in the jetty channel which request was not complied with, on the ground that, as he said, "the law expressly provides that the inspecting officer of the Engineer Corps (Gen. Comstock) shall execute this class of surveys you wish within the jetties."

The misstatements circulated in New Orleans and St

Louis having been contradicted by Mr. Eads, in a letter to the New Orleans *Times* and in a telegram to St. Louis, Major Howell, in a letter to the New Orleans *Democrat*, May 6th, made the following statements, in reference to the surveys made recently by him in South Pass:

"The surveys have been made at government expense, because needed to aid in solving the great problem presented at the mouth of the Mississippi. If the results had been available before the passage of the jetty contract, it is probable that the country would not have been saddled with the adventure. * * * The fact is, that on the day of the *Grand Republic* splurge there was at South Pass only a channel of twelve feet entitled to be called navigable, while at Southwest Pass there was a navigable channel of over eighteen feet.

"I know that on the day the *Grand Republic* visited South Pass the nucleus of a new bar existed one thousand feet in front of the jetties, and that a shoal had made out from the end of the west jetty three hundred and eighty feet toward this, and diagonally across the front of the jetties." Also, "that since the commencement of the jetty work the low water cross section of South Pass, one mile below its head, has been diminished one-sixth."

In a letter to Mr. Eads, on May 22d, E. L. Corthell, the Chief Assistant Engineer, controverts the statements of Major Howell, and states there has been a very marked and general increase in the depth immediately in advance of the jetties for nearly two thousand feet beyond them; and that the "nucleus of a new bar" one thousand feet in front of the jetties, is the remains of a mud-lump existing before the jetties were begun, and by their action diminished nearly one-half; also that recent soundings made across South Pass one mile below the head of it, show no decrease in section when compared with the Coast Survey soundings of the previous year; and he fur-

ther states that on the day of the *Grand Republic* excursion there was a navigable depth of fully sixteen feet entirely through the jetties. These statements were concurred in by Mr. Bayley, Resident Engineer, and by Max E. Schmidt, Assistant Engineer.

Immediately after the visit of the steamer *Grand Republic*, Captain M. R. Brown, United States Engineers (assistant of Gen. Comstock), commenced a survey of the jettied channel. Mr. Eads, believing that information in Captain Brown's possession would completely refute Major Howell's assertions, asked him for an official statement of the depths. This he declined to give, stating as a reason that he had not made his report to Gen. Comstock. Learning that the latter officer had just gone to the jetties, Mr. Eads telegraphed the Secretary of War as follows: "New Orleans, La., May 9th, 1876. Hon. Alphonso Taft, Secretary of War, Washington, D. C. Please instruct Gen. C. B. Comstock, now at Port Eads, to sound channel between jetties with me; likewise dredged channel through Southwest Pass bar, and furnish me with the results promptly. Major Howell has published a misstatement affecting public confidence in my work, and this information is required in justice to myself, and will benefit the public." Gen. Comstock remained at Port Eads one day awaiting instructions, but as no answer to the message was received, he left for New Orleans, declining to give any information, for the reason that he had not made his report to Gen. Humphreys, Chief of Engineers, U. S. A. A dispatch received from the Secretary of War, four days after, stated that Gen. Comstock had previously received authority and instructions for a complete survey of the jetty channel, and a copy of the results of his soundings would be furnished as soon as received.

On receiving this message, Mr. Eads, knowing that the receipt of the information would be delayed for sixty days

longer, telegraphed to the Superintendent of the Coast Survey, requesting that Marindin be permitted to give the results of his soundings in advance of the bar, so as to refute that portion of Major Howell's statements which referred to the re-formation of the bar, to which the following reply was received: "Regret Marindin cannot furnish results. Gen. Comstock will give all information required by law. Will write." Being determined to have the official disproof, if possible, Mr. Eads requested the Secretary of War to obtain it, and on July 19th the Secretary requested the Superintendent of the Coast Survey to furnish the War Department with a comparative chart of the soundings made May, 1875, and May, 1876, in front of the jetties.

Wishing to avoid a conflict with the United States Engineer Department, the Superintendent made a verbal declaration that he would not supply this information, even to the War Department, as he did not think they had any right to call for it. Mr. Eads then appealed to the Secretary of the Treasury to instruct the Superintendent to furnish the chart and an official statement of the results shown by it. This request was refused, on the ground that "provision is made in the said jetty act for the facts and information desired through the War Department." Being thus foiled in getting official disproof of this misrepresentation of Major Howell, Mr. Eads finally appealed to the House of Representatives, and a resolution was unanimously passed by that body, directing the Secretary of the Treasury to furnish the House the specific information asked for. The following is from the records of the House: "South Pass, Mississippi River. Mr. Conger, by unanimous consent, submitted the following resolution, which was read, considered and adopted: Resolved, that the Secretary of the Treasury be and he is hereby directed to furnish to the House the following information: First, a chart of soundings made by the Coast Survey last May in

front of the jetties at the South Pass, in the Gulf of Mexico. Second, a comparative chart showing the result of the survey of 1875, made by the Coast Survey, and the result of the last survey above named, so far as both surveys embrace the same area in advance of the jetties; and, Third, a statement of the average increase of depth in front of the jetties, and within the area embraced by both surveys, as indicated by a comparison of the soundings shown by the two surveys. July 29th, 1876, page 4,963, Forty-fourth Congress." On August 1st, nearly three months after the first attempt to obtain this information, it was furnished in a letter addressed to the Secretary of War by Superintendent Patterson.

The results of Marindin's survey, given in this letter, completely refuted the statements made by Major Howell, that a shoal was moving out diagonally in front of the jetties, and that the bar was advancing seaward. The following is an abstract of the letter, as far as it relates to these two subjects: "The survey of 1875, as well as that of 1876, shows a shoal about three hundred yards seaward of the bar. Comparing the two surveys, the river face of this shoal has receded thirty yards; its seaward face and center have advanced but little. Its contents above eighteen feet was, in 1875, equal to eight thousand cubic yards, and in 1876, three thousand seven hundred cubic yards, a decrease of about one half. In a square of seven hundred yards (or four hundred and ninety thousand square yards), directly in front of the bar, two hundred and sixteen thousand five hundred square yards have decreased in depth, and two hundred and seventy-three thousand five hundred square yards have increased in depth. The deposits within the same boundaries amount approximately to three hundred and eleven thousand three hundred cubic yards, and the scouring to three hundred and seventy-nine thousand seven hundred cubic yards, a difference in favor of scouring, of sixty-eight thousand four hundred cubic

yards, or an increase of depth over the whole area of 0.42 feet."

This square began about one hundred yards beyond the ends of the jetties. If the soundings of 1876 had been taken on that portion of the bar immediately at the end of the jetties, and the square had been located accordingly, a still greater increase in depth would have appeared; for on June 5th, Mr. Schmidt made a survey and calculation to ascertain what changes had taken place since May, 1875, on an area of fifty-one and seven-tenths acres, beginning at the crest of the bar and extending seaward two thousand seven hundred and thirty feet, in the direct line of the river discharge. The investigation showed that the scour exceeded the deposit by two hundred and six thousand four hundred and twenty-five cubic yards, equivalent to an average increase in depth of 2.47 feet.

Mr. Eads being foiled in his efforts to have an official statement of the depth of the channel furnished to him by the U. S. Inspector, General Comstock, and being refused the results of Mr. Marindin's survey of the outer slope of the bar, determined to address an open letter to the Secretary of War, through which that high officer, and the public as well, should be made to see the excessive injustice with which he was treated, in having all official disproof withheld from him, by which alone he would be able to expose the misstatements made over the official signature of an officer of engineers, in no way authorized to interfere with or report upon his works.

Accordingly, on the 23d of May, 1876, he addressed a letter to the Hon. Alphonzo Taft, then Secretary of War, in which he referred to the foregoing and other official acts of hostility and unfairness, on the part of General Humphreys and Major Howell. In this letter he calls the attention of the Secretary to the fact, that "The act directs the Secretary of

War to appoint an officer, whose duty it shall be to report the depth of water and width of channel secured and maintained from time to time, in said channel, together with such other information as the Secretary of War may direct. The grant expressly provides, that 'I shall be untrammeled in the exercise of my judgment and skill in the location, design, and construction of the works;' therefore, I did not suppose that another officer of engineers, and one, too, avowedly hostile to the undertaking, would likewise (without authority of Congress) be charged with the official duty of observing any part of our work or its results.

"Least of all did I suppose that he would be permitted to give to the public with perfect freedom, such unfavorable and unreliable information respecting it as might best seem to support the predictions of its failure, previously uttered so confidently by his chief and himself, and thus really trammel its construction by increasing my difficulties in providing means with which to carry it on."

He further calls the attention of the Secretary to the fact, that

"*After the jetty system was finally adopted by the last Congress*, General Humphreys published four essays, termed by him 'memorandums,' to prove that the jetties would be a failure; these were published as a part of his official report to the present Congress. They were at the same time excerpted from that voluminous document, and, illustrated with maps, were bound in pamphlet form and distributed throughout the country five months ago."

Referring to Major Howell's excuse for this remarkable conduct, Mr. Eads adds:

"Admitting General Humphreys' ability to complete discussions left unfinished by Congress, his justification in this case would have been more satisfactory had Major Howell informed his readers by what authority an officer of the

United States Engineers presumes to publish his gratuitous opinions at the public expense, or to indirectly criticise the President and Congress of the United States, for declining to be guided by the judgment of General Humphreys and Major Howell in this matter."

In this letter Mr. Eads makes the following requests of the Secretary of War:

"In view of the annoyance and embarrassments already suffered from the official antagonism of General Humphreys and Major Howell, and of the fact that their official positions give them the ability to continue their open or insidious opposition to this work (the one being Chief of the Corps of Engineers, U. S. A., and the other stationed in this city in charge of important engineering operations in the vicinity), I have to respectfully ask, that any further officious or unauthorized official interference on the part of these officers be interdicted, and that instructions be issued to the inspecting officer, authorized by the act and 'detailed' by you to make the examinations, to promptly supply me with any official information he may from time to time acquire, respecting these works and their results, which I may deem important to facilitate us in carrying out the intent of the grant, or in protecting us from misrepresentation; and that his reports hereafter be made directly to the Secretary of War, instead of through the medium of the Chief of Engineers, U. S. A., as the Secretary of War alone is, by the words of the grant, 'authorized and directed to carry into effect the provisions of the act.'"

The full text of this indignant protest will be found in Appendix 8, and it will well repay careful perusal. About the time it was written Mr. Taft ceased to be Secretary of War, and the Hon. J. D. Cameron was appointed in his stead. The following letter will show that the requests of Mr. Eads were complied with, and Gen. Humphreys and Major Howell were

interdicted from any further connection whatever with the jetty works, and Gen. Comstock was directed to report in future directly to the Secretary of War.

"WAR DEPARTMENT,
"WASHINGTON, D. C., *June 28th*, 1876.

"*Sir*,—I have the honor to acknowledge the receipt of your letter of the 20th inst., requesting in substance:

"*First*—That in future the inspecting officer contemplated in the act approved March 3d, 1875, for the improvement of the South Pass of the Mississippi River, be required to make his report directly to the Secretary of War.

"*Second*—That the duty of observing and reporting upon the progress of the work, the manner of its construction, the results accomplished by it, and all other matters relating to said improvement which the Secretary of War may direct, will henceforth be performed by the said inspecting officer exclusively.

"*Third*—That any official publications with reference to the said improvement will not be permitted from any other officer of the Engineer Corps.

"*Fourth*—That the Chief of Engineers be directed to discontinue all surveys of the South Pass and its bar, that are not under the direction of the said inspecting officer.

"*Fifth*—That the said inspecting officer be directed to furnish you or your authorized assistants any information he may possess or hereafter acquire, relating to the progress, effects, permanency, or probable success of the work.

"Your first request has been granted, and I beg to inclose you a copy of the letter directing it. To the second request I have to reply that the duty therein referred to will be performed by the officer assigned to it and his assistants exclusively. As to third request, it may be stated, as a general rule, that reports made by officers of the War Department

to the Secretary are not published without his consent. If any other officer of the Engineer Corps should be called upon for a report, notification thereof will be sent you. Your fourth request has already been carried into effect, as the Chief of Engineers on the 8th inst. directed Capt. C. W. Howell, the officer in charge, to make no soundings, current or other measurements of any kind whatever, in the South Pass, or on the bars at its river or sea ends, or in the sea at and off its mouth, but to limit his observations to the other passes and the main stem of the river, should such observations be necessary in the execution of duties heretofore assigned him.

"You will perceive by the inclosed copy of letter that Major C. B. Comstock, in accordance with your request, has been directed to furnish you or your assistant the actual results of the soundings that have been or hereafter may be made under his direction in the performance of the duties assigned him, in connection with the improvement of the channel between the South Pass of the Mississippi River and the Gulf of Mexico, under the act approved March 3d, 1875.

"Very respectfully, your obedient servant,

"J. D. CAMERON, *Secretary of War.*

"*To* JAMES B. EADS, ESQ., Washington, D. C."

Before these instructions were given, the results of the surveys were carefully kept secret from Mr. Eads and his assistants, and were not seen by him or the public until they were transmitted by Capt. Brown to Gen. Comstock at Detroit; by him to the Chief of Engineers at Washington; by him to the Secretary of War; by him to Congress; by Congress to the public printer, and by him back to Congress. They were then so old as to be of little interest or value to any one. (See Appendices 8 and 11 for full information on the preceding subjects.)

The misstatements about the depth and navigability of the jetty channel, which were circulated at the time of the visit of the *Grand Republic*, and which made such an injurious impression, were most effectually refuted a fortnight afterward by a measurement of the channel that was more satisfactory than that of the lead line.

Capt. E. V. Gager, of the steamship *Hudson*, of the Cromwell Line, had been from the first a friend of the undertaking, and had expressed a wish to run the first steamship through the new channel. When he went to sea from New Orleans in April, he requested his bar pilot, Capt. Richard Francis, to take careful soundings in the jetty channel prior to the departure of the steamship from New York, and telegraph him the result.

The *Hudson* was due at the mouth of the river in the afternoon of May 12th, in the morning of which day Capt. Francis sounded the channel thoroughly, and satisfied himself that it had the required depth. About 2 o'clock P. M. the steamer appeared, coming from the southeast and bearing for the South Pass. When she arrived off the bar she was boarded by Pilot Francis, Mr. Eads and others.

The *Hudson* is an iron steamship, two hundred and eighty feet in length, with a registered tonnage of one thousand eight hundred and seventy-two tons, and with a draft, at that time, of fourteen feet seven inches.

In reply to the inquiry of Capt. Gager if there was water enough for the steamer, the pilot stated that, at average flood tide, there was a channel of fifteen feet, but that the tide had turned at 10 o'clock A. M., and was then six inches down, still falling fast, and creating a strong current through the jetty channel. Capt. Gager promptly gave the order "Head her for the jetties." The pilot decided to run her straight up the channel and not to attempt, with so large a vessel, to make the turns necessary to follow the deepest water. With

intense interest we watched the steamer come in over the bar. We knew that nothing but her successful passage through the jetties could convince the public that our statements were correct, or restore the needed confidence in the work.

The pilot straightened up the steamship for the channel over the bar, the Captain rang the bell for full speed, and on she came like a thing of life, as if intent only upon proving that we had a navigable channel of sufficient depth. As long as she carried that "white bone in her teeth"—the great wave that her proud bows pushed ahead of her as she sped onward—we knew that she had found more than Major Howell's twelve feet, and she carried it continuously throughout the entire two and one-quarter miles of jetty channel, until she checked her course in the deep water at Port Eads. No event in the whole history of the jetties gave us such intense pleasure and satisfaction as the successful passage of this beautiful ship through the jetties. It is not too much to say that Capt. Gager, who took the risk and the responsibility of this trial trip, materially assisted the enterprise in one of its darkest hours; for the stubborn facts brought out by his brave action could not be gainsaid. They restored confidence in the jetties, and the much-needed loan was soon afterward secured for the further prosecution of the work.

CHAPTER X.

HEAD OF THE PASSES—GENERAL CONDITIONS DESCRIBED.

THE problem of how to deepen the inlet channel at the head of South Pass was far more difficult of solution than any presented at its mouth. To get the water out through one deep channel was a far more simple process than to get it into a small pass, through a narrow artificially contracted channel, located immediately between two great natural outlets.

In order to appreciate the difficulties of this problem, and to understand the plan of the work designed to solve it, a knowledge of the natural conditions prior to their construction is necessary.

The jetties and auxiliary works were artificial factors introduced into a problem in which were involved the difference in the length of the three passes, their respective volumes of discharge, surface slopes and depths and the character of bed, the bars at their mouths, and the gulf beyond them, with its currents and waves.

When the natural conditions then existing are more fully described, it will appear that an artificial change in any one of them from "Cubitt's Gap" to the gulf, must necessarily affect all the others. There is scarcely anything in nature more sensitive than the delicate adjustment of these mighty forces. The general quantities were known; the sections had been calculated from the soundings; the volumes discharged

ascertained by gauging; the slopes measured by careful observations and accurate leveling; the geological character of the bed obtained from microscopic examinations and chemical analysis, and the ratio of the sediment to the water that transported it, and the size of the particles of silt, discovered by delicate experiments and patient investigation.

No problem had ever before been solved in river hydraulics in which there were such tremendous forces and so many variable elements. Jetties had been built to deepen the bars at mouths of rivers, and dykes had been constructed to change the direction of currents, but the forces controlled by them were not only far inferior to those at the mouth of the Mississippi, but several were present here that were absent in similar works.

The theories evolved by scientists from their miniature experiments, and published for the use of the world, were in many cases calculated to mislead, rather than to enlighten.

The conditions at the mouth of the pass have been given already; it remains to describe those at the head of the passes. The sedimentary matter in the flowing water hides everything beneath the surface. The eye sees only the broad muddy river, the low banks fringed with willows, back of them the vast swamps of the delta overgrown with vegetation, and in the distance the waters of the bays and sounds.

The river preserves an average width of about half a mile to within eight miles of the head of the passes. From this point to Cubitt's Gap it widens to three-quarters of a mile; it then widens still more rapidly, and at the two points of land where the three passes separate, it is eleven thousand feet wide—more than two miles.

To aid in the examination of the river bed, and to obtain a clearer idea of its shape, let us suppose the water that now fills it, to be removed between two points—one, eight miles above the head of the passes, the other, one mile below it.

At the upper end of this basin the deepest part of the bed is ninety feet below the surface of the ground, and descent to it from either side is about eight feet in one dred feet, or one in twelve.

Going down the river to a point just below Cubitt's where the width is greater, we find the depth only sixty As we approach the head of the passes the river widens more, and the depth becomes still less. About one above the point where the passes diverge, we notice the ginning of a more rapid rise of the bottom, not toward banks but in the direction of the axis of the river. I ascend this slope until we reach the entrance of South we find ourselves considerably above the deep channel either side; that on the right is twenty-five feet below that on the left twenty feet, and the greatest depth these channels are much nearer the banks of the than the elevation on which we stand. If a perfectly zontal line could be stretched across between the east west bank, it would be fifteen feet above the ground w we stand, forty feet above the bed of the pass on the r and thirty-five feet above that on our left.

The hill or ridge where we are constitutes the shoal which the water must flow to enter the South Pass, the c nels to the right and left are respectively those of South and à Loutre Passes, and the depths over the shoals them were fully thirty feet.

From these channels and shoals, their direction, con and extent, we gather information that will show us how where the great volume of the river flows. These are marks that it has scored in the past ages, marking the t from which, though flowing over a bed of its own dep it has never varied. Whatever the causes are, they been sufficiently powerful to hold the successive floods in same channel year after year.


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At times the relative size of the passes has changed, but the position of the deep channels has remained the same. Since the velocity varies approximately as the depth, the strongest currents of the river are near the eastern and western banks, a considerable distance from the inlet channel of South Pass. According to this same law of velocity, the current flowing up on this shoal gradually decreases as the depth diminishes.

With this description of the shoals and channels of the river, we can appreciate the difficulty in forcing it to turn aside from its accustomed pathways, and excavate a new path through this formidable shoal.

Careful and repeated float observations revealed the fact, that there were well established lines of demarkation between the waters of each pass when they reached this shoal. At this point the depth of the water which entered South Pass was about thirty feet; its width about seven hundred feet, and its sectional area about twenty-one thousand square feet. From this point the neutral axes flared out like the mouth of a trumpet, until they were three thousand feet apart, where they reached the two points of land which separated the three passes.

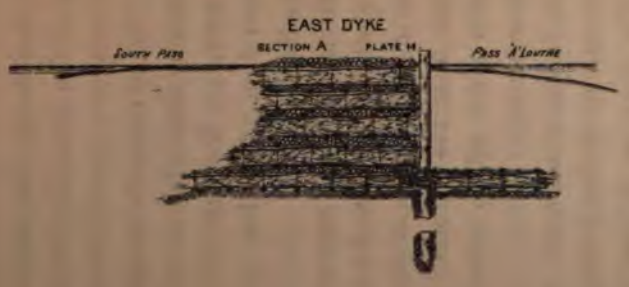
Mr. Eads, with the Advisory Board of Engineers, studied the subject carefully, discussed the various plans suggested for creating a channel through this shoal, and as an initial work, decided upon the construction of a dyke (called East Dyke), three thousand two hundred and fifty feet long, to extend from the point of land between South Pass and Pass à Loutre, with its upper end in twenty-four feet of water, and about six hundred feet east of the neutral axis between the currents of these two passes. The object of this dyke was to intercept a portion of the water flowing into Pass à Loutre, and deflect it into South Pass. The dyke curved to the westward with a radius of eight thousand feet. The loca-

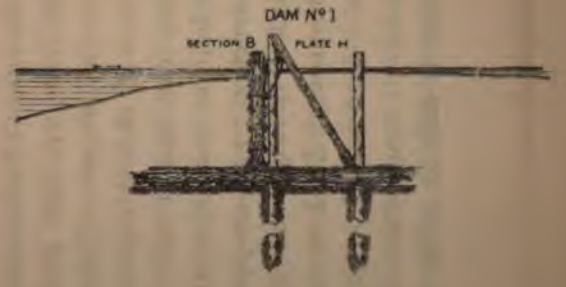
tion will be seen on Plate H, and a cross-section of it Plate 12. A parallel dyke was to have been placed al eight hundred feet to the westward of East Dyke, and wa extend from the island to a point opposite the upper end c The western channel near the island was to have been fir closed. The Advisory Commission say on this subject: " further prolongation of this work (East Dyke), and the ex tion of works on the west side, to be left for determina and observation of effects, produced by the construc recommended."

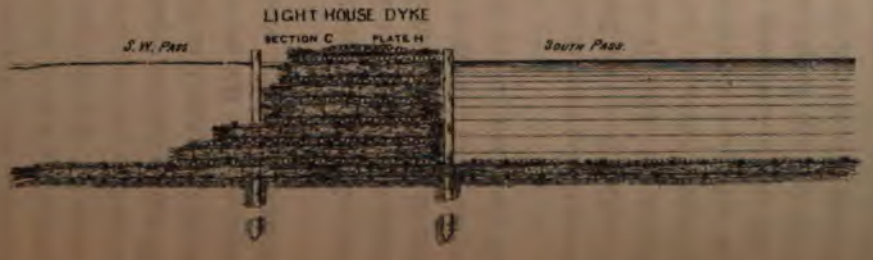
This design Mr. Eads was compelled to abandon; an see the costly dyke which he had built made comparati valueless, in consequence of the unfair treatment he recei at this time from the government (referred to in the pre ing chapter), the effects of which upon this work will presently explained.

This dyke was constructed with horizontal mattresse the same manner as the jetties, and was well ballasted stone. The dyke, as it was built up from the founda caused a retardation of the current near the bottom on up-stream or South Pass side, which caused a dep throughout the area where this retardation was felt. long as the current flowed over the top of the dyke as it gradually built up, this shoaling continued; therefor change in the progress of its construction was determ upon. Instead of building it up by continuous course mattresses from end to end of the dyke, the down-str end was built up above the surface of the water at once, the construction up-stream pushed as fast as possible, fir ing it to its full height as it progressed. As this was d an improvement in depth on the channel side was the res but as the dyke was of porous willow construction, the tlement due to compression, as it became filled with s ment, made it difficult to keep it above the surface du

PLATE 12.







SECTIONS
OF
WORKS AT HEAD
OF
SOUTH PASS
MISSISSIPPI RIVER

the river flood, and the water soon passed over the top of it into Pass à Loutre, several inches deep at low tide, and the resultant shoaling on the channel side satisfied us that the closure of the channel on the western side of the island, at once, would be necessary to produce such a head of water as would insure a rapid current in the direction of the dyke, and the desired deepening of the eastern channel. One effect of the dyke was to increase, in a slight degree, the flow of water into the western channel, and this caused an increase in the depth of that channel from twelve to fifteen inches, so that it became the better channel of the two. But as it was still only about seventeen feet deep, it barely sufficed to enable the Cromwell steamers to use the South Pass.

As the spring floods were over, it became an imperative necessity to push the construction of the works at the head of the pass, so as to have the requisite depth of water there as soon as twenty feet through the jetties should be secured, in order that there might be no difficulty in the way of receiving from the government the first payment of five hundred thousand dollars.

As we have stated in chapter IX, Mr. Eads had, in May, appealed to the Secretary of War without success, to have an official measurement and statement of the depth of the jetty channel published, to refute the misrepresentations of Major Howell. He had appealed to the Superintendent of the U. S. Coast Survey soon after, to furnish him an official statement to refute the same officer's misstatement respecting the reformation of the bar in front of the jetties, with no better success. He had appealed to the Secretary of the Treasury, and finally, on the 29th of July, to the House of Representatives, before he succeeded in breaking through the official jealousy and hostility which had locked up from the public the evidence of his success; and although Mr. Secretary Cameron had with most commendable decision

issued an order effectually interdicting General Humphreys and Major Howell from any further official interference with the jetties, and had directed General Comstock, the inspector, thereafter to report directly to him instead of to General Humphreys, and had ordered General Comstock, on the 29th of June and 31st of July, 1876, to furnish Mr. Eads "the results of actual soundings, that have been or may be hereafter made under your (his) direction, in connection with this improvement"—yet it was necessary to appeal again on the 7th of February, 1877, to the Secretary, for an order directing General Comstock to instruct his assistant, Captain Brown, "to give me (Mr. Eads), or my chief assistant engineer at the jetties, the results of his soundings," because Captain Brown could not, even with these orders to General Comstock, furnish, up to that time, an official copy of his soundings until they had gone from Port Eads to Detroit (at the great lakes, where General Comstock was stationed), for his inspection and approval; nor did he feel authorized, even as late as February, 1877, until more explicitly instructed by General Comstock, to give the results of his soundings to the chief assistant of Mr. Eads, in his absence.

Although the channel through the jetties, as early as July 1st, had attained a depth of at least nineteen feet, Mr. Eads was deprived of the advantage of having this fact officially certified to the public by the proper officer, while every means were used by his enemies to create the belief that no such channel existed. The only absolute proof of our success up to this time, beyond our own controverted declarations, was the fact that the New York and New Orleans Cromwell Steamship Line was using the jetties.

On the 27th of May the steamer *New Orleans* of that line went out drawing seventeen feet three inches. This was the maximum depth during that summer in the western channel

ead of the pass, while the greatest depth through the as at least eighteen inches less.

s plain then, that if the original plan of improvement head of the pass was carried out, and the western l closed, we must give up for several months the only ated evidence we possessed of a substantial channel ement—namely, the semi-weekly passage of these s—for the eastern channel would not suffice for them epened. It was, therefore, a question, not so much neering as of finance, that was presented. If the west- nnel were closed, and the Cromwell steamers were ed from using the pass, it would at once have been r granted that the statements of our enemies were and that the improvement of our channel was only ary; that the bar at its mouth had reformed, and shifting sands had made the channel between the jet- hazardous for the Cromwell Line to use any longer. ould be stated in this connection that the channel Southwest Pass bar, was being maintained by the he United States dredge-boats, *McAlester* and *Essayons*, verful propeller vessels, and that their operations were ed under the orders of Major Howell. The jetty had now become so deep as to rival that maintained Southwest bar. Near the latter is situated a village Pilot Town, the residence of nearly all the pilots em- at the passes. These men were almost without ex- opposed to the work at South Pass, for they thought w in its success a transfer of their field of labor from nity of their little town to a distant locality, and a eed of pilots. If the Cromwell line had been forced y cause to use the Southwest Pass channel again, en would have hastened to publish that fact, to the f the jetty enterprise; and the same may be said of boat interest, which from the first was hostile to the

work. On the other hand, the abandonment of the eastern channel involved the loss of a dyke three thousand two hundred and fifty feet long, which had cost $180,000. For if the channel were to be made on the western side of the island, this dyke would be practically useless. Notwithstanding this loss, Mr. Eads determined under these circumstances to abandon his original design and deepen the western channel. Had he been promptly furnished, as in common justice he should have been, with the official certification of the actual condition of the channel, as often as it was measured by the United States inspecting officer, this change would not have been made, and the channel into the pass would have been a straighter and better one, as will be seen by examining the alignment of East Dyke, and noticing its conformity with the direction of the pass. As it is, East Dyke and the altered plan must remain forever a monument of official jealousy and opposition.

The explanation of the phenomena which occurred at the head of the pass about this period—namely, between the time of closing Grand Bayou, in June, and the 18th of August, following—is so clearly stated in a report made by Mr. Eads, on the latter date, to the South Pass Jetty Company, that the following extract from it is given:

"Our original plan of improvement contemplated the closure of Grand Bayou. This outlet is situated midway between the upper and lower ends of the pass, and discharges twenty-three per cent. of its volume. Its closure would consequently add about thirty per cent. to the water passing out through the jetties, by which the current below this outlet would be largely increased, while the current in the pass above would be proportionally retarded, until the channel below the outlet should be sufficiently enlarged to restore the normal velocity. Enlargement and deepening were consequently to be anticipated below, while shoaling would be the result naturally expected above.

"The head of the pass is divided by an island into two inlets of nearly equal magnitude, and the original plan of improvement contemplated the ultimate closure of one of these. It was believed that if Grand Bayou and one of these inlets were closed simultaneously, the expected shoaling above the pass would not occur, because, although the volume entering the pass would be temporarily lessened by the dam at Grand Bayou, the size of the entrance into the pass would be reduced in a greater ratio by the closure of one of these inlets, and the retardation of current across the shoal above the other inlet would thus be prevented. It was therefore determined to close the inlet and bayou at the same time. Some unavoidable delays, however, retarded the construction of the dam at the inlet until five or six weeks after the bayou was closed. During this interval the deposit which had been feared occurred upon the shoal, until the available depth over it was reduced to about fourteen feet, and the steamers referred to were compelled to temporarily abandon the use of the pass. Since the closure of the inlet, however, the depth has been increasing, and the large steamers *Knickerbocker* and *Hudson*, of the Cromwell Line, have again crossed this shoal, in going and returning through the South Pass during the last fortnight. From twenty feet on the upper side to twenty feet on the lower side of this shoal the distance is about one thousand five hundred feet. The works in course of construction here comprise one dam one thousand one hundred feet long; another one thousand eight hundred feet long; and a dyke three thousand two hundred feet long; all completed above high water; also three other dykes in the course of construction, having a total length of two thousand two hundred feet. The most effective part of these will probably be completed within the next thirty days.

"The same principle which has proved so successful at the jetties, namely: the concentration of the flowing water, forms

the basis of the plan for the reduction of this shoal, and the completion of the works designed cannot fail to be equally successful, while their execution is far less expensive and difficult, because they are sheltered by the river banks from the storms of the gulf. It is possible, however, that the effect will not be as rapid as we desire, because the low water season is approaching, and the river discharge will be diminished very considerably, by which the scouring action will be lessened.

"It has been asserted in some of the public journals, that the construction of the works necessary to contract the flow and deepen these obstructions, must have the effect of permanently lessening the quantity of water which entered South Pass at the time our works were commenced, and would, therefore, cause a permanent reduction in the size of the pass. It is important to consider whether there is any cause for any apprehension of such result, inasmuch as it has been stated that it has already occurred.

"Repeated measurements of the pass have been made by my assistant engineers at three different points, one about a mile below the head of the pass, one above Grand Bayou, and one below it. The result of these justifies me in declaring emphatically that there is no cause whatever for any such apprehension. A few facts, however, which have been developed by our works, will probably be more potent in removing any fears upon this point, than a volume of theorizing.

"The entrance into Pass à Loutre was contracted six hundred feet in width by one of our dykes, and it might reasonably be inferred that the temporary flow into the pass being thereby greatly reduced, a permanent diminution of its size would occur. The effect of this contraction was to *raise* the surface of the water *above* our works, while *below* them the reduced supply caused the surface to be *lowered*. An increased slope was thus given to the surface of the water through this

contraction. The current is caused by the surface slope of the river. Resistance to the current results mainly from the friction between the water and the bed of the stream. This frictional resistance being lessened to the extent of six hundred feet, while the impelling force or surface slope was increased, a greatly increased velocity of current of course resulted, and induced rapid scouring, by which, in a few weeks, the size of the pass at the point of contraction was entirely restored by an equivalent amount of deepening. Undoubtedly, while this deepening was progressing, an increased quantity of water was being thrown into the two other passes; and if this extra quantity had continued to flow into them, permanent enlargement of each would have resulted, but experience at the jetties has shown that the enlargement of channel, which occurs from an increased flow, begins at the upper end and advances down stream. This result would inevitably follow an increased flow into either of the other passes by the contraction of Pass à Loutre; but before this enlargement of South Pass and Southwest Pass could extend any great distance down, the recovery by Pass à Loutre of its full section was accomplished, and the temporarily disturbed equilibrium of the three passes was restored.

"A similar result may reasonably be expected from the closure of the east inlet into South Pass.

"The flow into this pass will unquestionably be temporarily lessened, and the excess will be temporarily thrown into the other passes. An enlargement of the upper ends of these passes must at once commence, but at the same time the contracted entrance into South Pass must, from the same cause, commence also to enlarge, and in proportion as the enlargement of the latter progresses, the head of water temporarily raised by the works must be lowered, and the extra flow into the other two passes must be diminished, and finally cease altogether. In other words, while the river will have only

half a mile in length of enlargement to make at the h
South Pass to recover its equilibrium, it must enlarge
west Pass through its entire length of seventeen miles
any permanent alteration in the respective volumes
through the two passes can take place. While the r
of the shoal is progressing, a considerable portion of
be found deposited in the deep water immediately be
where no contraction has occurred, and where the first
tion of velocity will be felt, and from whence it will b
ually removed as the enlargement above restores the v
below."

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CHAPTER XI.

DETAILS AND RESULTS OF WORKS AT THE HEAD OF SOUTH PASS, 1876–1777.

THE locations, with plans of the foundations of all works constructed at the head of the pass, are shown on Plate H. They will now be described in detail, in the order of their construction.

The preliminary work was commenced on the 3d of June, 1876. This was called "Cross Dyke," and extended from the island to East Dyke, a distance of one thousand and seventy feet.

A row of piles was driven eight feet apart, and a waling strake was bolted to them, against which mattresses were tilted in a vertical position. During the following night several of these mattresses were undermined and the piling washed out.

The causes of this disaster were:

First.—The high stage of the river.

Second.—The unstable foundation (having been formed by recent deposits), and

Third.—The absence of any foundation mattresses.

As soon as practicable, mattresses were laid horizontally the whole length of the dam. Through these a second row of piles was driven, about ten feet above the old row. After the irregularities caused by the wash-out had been leveled up by several courses of mattresses, a new dam of tilted mattresses was built above the new row of piles.

DAM No. I.

This work was begun in July, 1876. Its initial point w seven hundred and fifty feet below "Cluster." It extend nine hundred and ninety feet, at right angles with the E Dyke, and connected with it; thence seven hundred a eighty-five feet in a more southerly direction, and at angle of twenty-five degrees with the first section. T depth of water was quite uniform, being about twelve fe except at the west end, where it was fifteen feet. Gui piles twenty-five feet apart were driven fifteen feet belc the line of the dam, for sinking foundation mattresse Anchorages or platforms were built one hundred and sevent five feet above the line of the dam, and one hundred a fifty feet apart. They were constructed by driving thr piles, eight feet apart, in the form of an equilateral triangl at a height of two feet above the level of the water, horizo tal timbers six inches by twelve inches, were bolted to the On these timbers, which were about eighteen inches belo the tops of the piles, planks were spiked for a platfor From these anchorages the mattresses were dropped their position above the guide piles by means of long lines.

After the mattress had been placed in position, a fl loaded with rubble rock was lowered from the anchorag so as to rest against the up-stream edge of the floating ma tress. The workmen distributed the rock over the mattre until it was nearly sunken below the surface. They the threw the rock upon the upper edge of the mattress, whic sunk below the surface; and the flat, by means of the lin leading to the anchorages, dropped down over it, the me in the mean time throwing the rock upon it as fast as po sible. The sounding lead was used to ascertain when lay smoothly on the bottom. The foundation mattresse

were one hundred feet long, thirty-five feet wide, and twenty-two inches thick.

After they were placed two rows of piles were driven through them, one five feet from the lower edge, with the piles fifteen feet apart, and the other seventeen feet, with the piles ten feet apart. A waling strake was bolted to the down-stream side of the upper row, two feet above average flood tide. These two rows of piles were braced as follows: A round pine pile sixty feet long, was held in a horizontal position above the water by a steam pile-driver scow. The braces (five inches by twelve inches) spaced ten feet apart, the upper ends resting on the waling timber, were abutted against this horizontal pile, and secured to it by iron straps or yokes, which passed around the pile and were bolted to the upper and lower edge of the braces. The pile with the braces attached was forced to the bottom, where it rested on the foundation mattress and against the up-stream side of the piles; the upper end of the braces was fastened to the piles of the upper row by screw bolts. The braces stood at an angle of about forty-five degrees with the piles.

Near the west end of the dam, where the water was deeper, round piles were used for braces, to give the dam greater strength and stiffness. The tilted mattresses were thirty inches thick, one hundred feet long, and their widths corresponded to the depth of water. When in position, the upper edge was about two feet above average flood tide. Small straight willows were used, so that the dam might be less pervious to the flow of water. The edge resting on the foundation mattresses was brushy, the butts of the willows being placed at the upper edge. Four rope lashings, twenty-five feet long and one and one-quarter inches in diameter, were secured in the upper side of the mattress during its construction.

The tug pulled the mattress off the ways, towed it to th anchorage immediately above where it was to be placed, an left it hanging to it by the head lines. The pile-driver sco was pulled up to the anchorage and alongside the brus edge of the mattress, which was lashed to the deck of t scow, the lashings being drawn taut by the engine, to ke that edge partly out of the water. The lashings that h been built into the other edge of the mattress were cross alternately, so as to form two loops or bridles, into whi the pile line and the hammer line were respectively ma fast. The driver scow with the mattress alongside, w dropped down from the anchorages broadside to the da A strain was taken upon the lines, so as to lift the top ed of the mattress out of the water. The lashings holding t brushy or bottom edge to the deck of the driver, were let all at once; the current passing under the driver forced th edge under the water, and, with the driver scow followi closely, the mattress came quickly against the piles in a v tical position. If necessary, one end or both, and sometim the whole mattress, was raised up by the pile driver engi in order to place it in a vertical position. The lashings, wi sometimes chains in addition, were made fast to the wali strake and piles, to hold the mattress in place. This da was finished on August 20th.

During its construction the river fell from 8.5 on the C rollton gauge to 2.0, so that the effect of the dam in deepe ing the channel was very slight.

There was a slight current through the dam, the veloci being about one-quarter of that in the channel.

This slackening of the current below the dam, and in t eddy that formed in the channel west of it, caused a sli deposit between the dam and the island during the low riv Another effect of the dam was the lowering of the surface the water below it to such an extent, that at ebb tide th

was a current over the East Dyke flowing from Pass à Loutre into South Pass.

Foundation mattresses were laid for a dyke parallel with the current at the west end of the dam. These mattresses were one hundred feet by thirty-five feet by two feet, and were laid on each side of a central row of piles connecting with the foundation mattress of the dam, and extending down stream four hundred feet.

A detailed record was preserved of the materials and labor in Dam No. I., and in the four hundred feet extension down stream. The estimate of the cost of this work to the contractor was made up from this record, and will be found in Appendix 9. A cross-section of this dam is shown on Plate 12, facing page 124.

DAM No. II.

This dam commenced at the western shore of South Pass, near the lighthouse, and extended out four hundred feet into the channel. The foundation mattresses were laid about the last of August, 1876.

Their dimensions were one hundred feet by thirty-five feet by twenty-two inches. A row of piles was driven through them twelve feet from the lower edge, about twenty-five feet apart, except over the one hundred feet next the channel, where they were ten feet apart. A waling strake was bolted to this section, against which a tilted mattress was placed.

Between the shore and the tilted mattress the dam was raised to the surface by two courses of mattresses laid horizontally, on which loose willows were placed. The maximum depth of water was twelve feet, and decreased gradually from the channel end of the dam to the shore line. The line of a dyke known as Lighthouse Dyke was established at the end of the dam, parallel with Island Dyke (the dyke at the west

end of Dam No. I.), and eight hundred and fifty feet from to form the west side of the channel. A line of piles ten f apart was driven from the end of the dam two hundred up stream and four hundred feet down stream. Foundat mattresses thirty-five feet wide, twenty-two inches thick, varying in length, were placed on each side of the up-stre row of piles for the foundation of this dyke. A wal strake one hundred and seventy-five feet in length bolted to the channel side, and tilted mattresses were pla against the piles on the shore side. This work was finis September 8th, 1876.

ISLAND DYKE.

In order to reach the twenty feet contour at the up edge of the shoal, and at the same time to define the east line of the channel, Island Dyke was extended up stre eight hundred feet above Dam No. I. A row of piles first driven the whole length of this extension, against east side of which foundation mattresses were sunk, thi five feet wide and twenty-two inches thick connecting v the mattress of Dam No. I., and extending sixty feet ab the upper end of the piling of the dyke. At the end of row a cluster of twelve piles was driven and drawn toget by a chain, on the top of which a platform was pla about six feet square, which was used as an instrument tion for locating soundings and floats. This station, ca "New Cluster," is shown on Plate H. The main row of pi eight feet apart, was driven through the foundation n tresses, and ten feet east of the row of guide piles. A ing strake was bolted to the west side of this row, three above average flood tide, against which eight hundred li feet of mattresses were placed, each mattress being one h dred feet long, twenty feet wide, and thirty inches th

Small choice willows were used, and the mattresses were constructed with unusual care to insure compactness. The ends of the mattresses were pulled tightly together, after being raised to a vertical position, and they were securely chained and lashed to a waling strake. The top of the mattresses was three feet above average flood tide. Braces of two inch plank connected the two rows of piles. The work was completed on September 15, 1876. In October another course of mattresses of the same dimensions was placed against the first, breaking joints with them. This dyke with its two courses of mattresses, was nearly impervious to the flow of the water. An eddy was formed on the west side of it, extending about three hundred and fifty feet into the channel.

SOUTHWEST PASS SILL.

It was evident, that, while the original plan contemplated works in the entrance of South Pass only, the results of these works would compel an extension of the system so as to embrace the whole river; a system that would check the temporary loss of volume, stop the deepening in the other passes, and restore to South Pass its full normal volume and maintain it. The only way to accomplish this was to control and reduce the flow into Southwest Pass and Pass à Loutre. If this had been done by dykes, built to the surface of the of the water from the east and west shores of the river toward South Pass, with no protecting apron on the bed of the two larger passes, the results, no doubt, would have been similar to that of East Dyke upon Pass à Loutre; that is, the two larger passes would have quickly recovered their sectional area; their depths and velocities would have been greater than formerly, and the direct consequence of these new conditions would have been the still further deterioration of South Pass, and a further gain of water by the two larger

passes. Soon after the construction of Dam No. I. an Lighthouse Dyke, it was decided to build a submerged da or mattress sill entirely across Southwest Pass, not with t intention at that time of contracting its original section, b of preventing its further enlargement, so that on the rise the river in the spring, the works recently built should a more energetically on the South Pass channel, and n deepen Southwest Pass, as East Dyke had deepened Pass Loutre. The location of the sill can be seen on Plate I Its eastern terminus was six hundred and forty feet abo the end of dam No. II. Its western terminus was the we shore line of Southwest Pass. The total length of the wo was three thousand one hundred and seventy feet, or fro the batture, where the first mattress was laid, two thousan eight hundred and forty feet. The depth of water over th batture or submerged bank was one foot at the shore lin and three feet at the edge of the channel at low water. I the next three hundred feet the water deepened to twenty eight feet. From this point there is a more gentle slope, th depth reaching thirty-three and a half feet, at a distance c fifteen hundred feet from the shore line; thence the dept decreased uniformly to eighteen feet, at the junction of th mattress sill with the Lighthouse Dyke.

Work was commenced September 7th, 1876, by buildin anchorages, which were spaced one hundred and fifty fee apart. The guide piles for the lower edge of the mattresse were driven fifteen feet apart, beginning three hundred an eighty-five feet from the shore line, in four feet of water.

The first three mattresses were placed September 21s their dimensions were one hundred feet by thirty-five feet b twenty-two inches, and their position was lengthwise wit the piling. The east end of the last mattress was in twent six feet of water. Two days afterward an attempt was ma to sink three mattresses beyond these, each one hundred fe

by fifty feet by twenty-two inches. Although the river was at a low stage (the reading on the Carrollton gauge being 4.0), the current was so strong that the mattresses, when nearly in position, pulled the anchorages over, broke through the guide piling, and were saved with difficulty. They were pulled up along the shore by the tug, and were placed as second and third tiers on those sunken on the 21st.

The size of the mattresses was then changed to sixty feet by thirty feet by twenty-two inches. These were handled very easily if placed lengthwise with the current. After sinking six, the dimensions were changed to seventy feet by forty feet by two feet, and this size was carried through the entire work. In order that the position of each mattress might be correctly plotted for future reference, every twelfth pile was located carefully by a transit, and the place of each mattress in reference to the piles, which were numbered consecutively, was accurately noted.

In order to avoid any more accidents, the anchorages were built more securely; the timbers were all six inches by twelve inches, and were well bolted to the piles. Above the platform, in a line with the current and at a distance equal to the depth of the water, two large piles were driven close together. Into one end of a seven-eighths inch chain, about fifty feet long, a large ring was forged, by means of which a loop was formed, which was slipped over the two piles. The running end of the chain was pulled taut by the engine of the pile-driver, and made fast to the up-stream pile of the platform. By this means the anchorages were not only rendered strong enough to resist the severe strain caused by the pull of the mattresses, but were greatly stiffened, and the swaying motion caused by the current was prevented. The remaining two piles of the platform were used as snubbing and fastening posts for the mattresses. Two head lines were built into each mattress in the manner employed at the jetties. When the mattresses

were brought from the Jump by the steamboat they were tied to an anchorage near the shore, about one-half mile above the sill. The tug, with the assistance of the yawl crew, brought the mattress to the anchorage immediately above the sill, and placed it nearly in its proper position. The pile-driver scow was placed on the west side of the two piles that had been driven about twenty-five feet apart in the eastern edge of the last mattress before it was sunken. The floating mattress was brought down to its position and at the same time hauled closely against these two side guide piles by means of a line made fast to it from the steam winch of the pile-driver. The mattress was secured to each of the piles by rope lashings, which were left sufficiently slack to slide down the piles. While this was being done the tug brought down another mattress; the line was run to it by the yawl crew of the pile driver; it was pulled snugly to its place against the first mattress, and the two mattresses were securely lashed together at the upper and lower ends. Fleets composed of three or four mattresses were thus brought into position and lashed together while floating. The pile driver was then taken to the opposite side of the fleet and two piles were driven in the edge of the eastern mattress and lashed as before. This plan, by avoiding gaps and the overlapping of mattresses, prevented a scour between or under them. There was one continuous mattress carpet, seventy feet in width extending the whole length of the sill.

It was necessary to use great care in sinking the mattresses for the impact of the strong current often brought a severe strain upon the lines leading to the anchorage, and unless the mattress went to the bottom in a perfectly horizontal position, neither lines, anchorages, nor guide piles could prevent it from breaking away from its fastenings. On the 21st of October, the sill having reached a distance of two thousand feet, an opening about seven hundred and fifty feet wide was

made through the guide piles and anchorages for the benefit of navigation. The piles in this opening were broken by the tug pulling down the piles, which invariably broke off in the mud at the bed of the river, this being the fulcrum of the lever. The broken piles were generally secured, hauled ashore and sharpened to be used elsewhere. The last mattress of the sill was laid on November 6th. The whole number of mattresses placed was seventy. Three thousand and thirty-three cords of willows were used in their construction, and one thousand five hundred and fourteen cubic yards of stone were required to sink and properly load them, the ratio of stone to mattress work being about one to ten. After the sill was completed, the guide piles and anchorages were removed, and nothing indicated to the eye the presence of this important work, except the difference in the appearance of the water surface above and below the sill, which, with certain directions of the wind, could be plainly seen the whole length of the work, revealing the fact of a head of water above it, which, though slight (being only the fraction of an inch), produced important results.

EXTENSION OF LIGHTHOUSE DYKE.

This dyke was extended four hundred and seventy-five feet to a connection with the sill. The guide piles for the foundation mattresses, were driven in a line with the piling of the dyke. Mattresses thirty-five feet wide and two feet thick were laid on each side of this piling. The guide piles were then broken off at the top of the mattresses, and permanent piles were driven ten feet apart and fifteen feet east of the first row. The dyke was then built up on the west side of these piles to the surface of the water, with mattresses laid horizontally. This plan gave a foundation fifty feet wide; the second course was forty feet wide, the third

thirty-five feet, the fourth, thirty feet, and the fifth, twe
eight feet. This extension was finished February 22d, 1
A protecting mattress apron thirty-eight feet wide, was
on the east side of the foundation mattresses, upon which
laid a second course, twenty-five feet wide. .The rise of
river about the last of January came very suddenly, ri
on the Carrollton guage in nine days, from 0 to 7.5.
wave on reaching the head of the passes, found the entr
of the South Pass obstructed. A very strong current
deflected from "New Cluster" against the Lighthouse D
striking it with the greatest force about two hundred
above the dam. The surface of the water in the pass
lowered by the obstructed entrance, producing a hea
water of two or three inches on the Southwest Pass sid
the dyke. At the point where the tilted mattresses of
dyke joined the horizontal mattresses of the perma
work, the current broke through, washing out the piles
throwing down the tilted mattresses. The strong curr
twenty feet deep, that rushed through this opening
South Pass, was at right angles with the current entering
pass from "New Cluster." The meeting of these two
rents produced whirls and vertical eddies, which made
excavation in the channel, in which there was a deptl
water of about forty feet, still further undermining the r
tresses. The effect of this extraordinary disturbance exten
below the dam, washing out the guide piles over the wl
distance of four hundred feet. The break through the d
was filled up with considerable difficulty, by five or
courses of mattresses laid horizontally. Protecting r
tresses were laid in the channel, extending eighty feet f
the dyke. The whole space between the dam and the
manent dyke was built to the surface with horizontal r
tresses, and afterward raised about three feet above aver
flood tide, with loose willows and stone. The interior a

between the dam and the dyke was reinforced by mattress work.

A cross-section of this work is shown on Plate 12, facing page 134.

ISLAND DAM.

This dam was intended to take the place of Cross Dyke, and of a board dam, which had subsequently been constructed below it, but had been quickly washed away. The new work was a permanent structure, and crossed the eastern channel about one hundred and fifty feet below Station "O'Brien," and connected the island with the east bank of the pass. The average depth of water in which the dam was built was twelve feet; but near each shore it was eighteen feet. The foundation on which the dam rested was the soft material which had been deposited by the river during the previous year, and later by the dipper dredges which used this place for a dumping ground.

The dam was six hundred feet long. The first course of mattresses was laid January 25, 1877, and the dimensions were one hundred feet by forty-five feet by three feet. The upper edge of this and the succeeding courses was supplied with inch boards, placed immediately behind the first row of pins, to prevent leakage through the willows. In placing the mattresses they were taken around the foot of the island and forced against the current by the tug and the pile-driver up to the lower side of the piling.

The second and third tiers of mattresses were thirty feet wide, the fourth twenty-five feet, and they were all three feet thick. These courses raised the dam to the surface of the water, except near the banks, where it was raised by mattresses that were made to fit the irregularities of the surface. A protecting apron of mattresses was placed above the dam to stop a scour that had commenced under it. A row of piles

was driven through the dam close to the lower edge
upper course of mattresses, and a waling strake was
to both rows of piles. After the dam had settled belo
surface of the water, a continuous mattress was built in
on the waling strakes by means of skids placed across
The skids were drawn out by the tug and the ma
dropped to its place. Two courses of mattresses, eac
and one-half feet thick, were built in this way, and th
was then raised about two feet above the surface of the
by loose willows and stone. A cross-section of this d
shown on Plate 13.

ISLAND DYKE.

(Between Dam No. I. and the Island.)

About the first of February, 1877, foundation matt
one hundred feet by thirty feet by two feet, boarded o
eastern edge, were laid from the island to a point four
dred feet below Dam No. I., where they connected wit
mattresses laid the previous year. The total distance
Dam No. I. to the island was one thousand six hundre
forty feet. The average depth of water was about t
feet.

DREDGING.

To insure immediate results from the works construc
was decided to dredge a channel entirely through the
about midway between the dykes. A contract was made w
N. Kimball, of Mobile, to excavate forty thousand cubic
He commenced work September 16th, 1876, with a
dredge. On November 16th, two other dredges tha
been chartered from the city of New Orleans comm
work. A narrow channel about eighteen feet deep
dredged through the shoal. These three dredges cont

PLATE 13.

ISLAND DAM
SECTION D. PLATE H



UPPER DAM & ISLAND DYKE
SECTION F & G. PLATE H.



UPPER DAM
SECTION E. PLATE H.



SECTIONS
OF
WORKS AT HEAD
OF
SOUTH PASS
MISSISSIPPI RIVER

SCALE OF FEET

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work with intermissions, until February 3d, 1877. The tal number of yards removed was about fifty thousand.

Several lines of soundings taken on February 3d, showed a ast depth through the shoal of twenty-two feet, a maximum pth of thirty-two feet, and a twenty feet channel one hun- ed and ten feet wide. For several days previous the cur- nt had been so strong that it was almost impossible for the chors to hold the dredges. The whole shoal seemed to be oving.

RESULTS OF THE WORKS.

The changes in the eastern channel caused by the East ke have been described.

The effects of the works subsequently constructed were as lows: The surface of the water was raised above "New ster," and lowered in the pass below the works. While slope of the river above the works was only 0.024 foot mile, and that of the pass below the island but 0.088 foot mile, the slope from "New Cluster" to the foot of the nd was 0.505 foot, more than six inches per mile. This aordinary slope through the inlet channel produced a ng current, quickly affecting the shoal.

eneral Comstock, in his report of March 16th, 1877, page peaks as follows of the effects of this rise: "The rapid rise luced a marked scour in the channel between the two T- ls, and on February 5th, when the reading at the Carroll- guage was 7.60 feet, the minimum width of the twenty- channel into the South Pass was about one hundred and nty feet, while twenty-two feet of water could be carried ugh. On March 7th, the twenty-two feet curve had a t width of about two hundred feet, and the soundings, ch are not very close, indicate that 23.9 feet of water d be carried into the South Pass from the Mississippi er."

The channel developed very rapidly. On the 13th of April 31.2 feet could be carried from "New Cluster" through the shoal, and the channel above "New Cluster" had improved, so that 24.4 could be carried from the river into the pass, and the twenty-four feet channel was about two hundred and fifty feet wide. A calculation from a survey made June 6th, 1877, showed that four hundred and fourteen thousand four hundred cubic yards had been scoured out of the shoal at the head of the pass.

The general effect of our works upon the head of the passes may be seen from a survey made on February 26th, 1877, from which cross-sections of the three passes were plotted. In South Pass, on a line drawn from near the end of Dam No. II. to East Dkye, at a point four hundred and fifty feet below Dam No. I., there had been a deepening in the western channel of sixteen feet since May, 1875, and a shoaling over the eastern channel of ten feet. On a line extending east of East Dyke across Pass à Loutre it had shoaled fifteen feet for a distance of two hundred and fifty feet, then deepened fifteen feet, with an average deepening of six feet entirely across the eastern portion of that pass.

In Southwest Pass the average deepening was about two feet.

The location, description and results of the works constructed at the head of the passes during the first two years are thus fully given to exhibit the method of solving the most difficult problem connected with the enterprise. The works described, no doubt injuriously affected the channel development at the mouth of the pass, and delayed its accomplishment many months by temporarily reducing the flow into South Pass.

GRAND BAYOU.

Some of the effects of the works at Grand Bayou have been

alluded to incidentally in the discussion of the head of the pass question.

The head of this bayou is five and one-quarter miles above the South Pass lighthouse. It had all the characteristics of a pass—a shoal at its head over which there was twenty feet of water, a channel about thirty feet deep and five miles in length, and a bar at its mouth with about three feet of water over it. The width of this bayou was about two hundred and seventy-five feet, and the area of its section about five thousand square feet. This bayou discharged twenty-three per cent. of the total volume of South Pass. In December, 1875, work was commenced on a dam at the head of the bayou. A line of piles was driven across it and four foundation mattresses were placed above them. This location was selected on account of lesser depths, but involved a diagonal current which interfered with the work so much that a new location was selected for it, three thousand seven hundred feet below the head of the bayou, where the width between the banks was two hundred and sixty feet and the central depth thirty-one feet, and where the dam could be built at right angles with the current.

Work at this location was commenced on the 16th of March, 1876. Two substantial anchorages were built two hundred feet above the lower line of the dam, dividing the bayou into three nearly equal spaces. The mattresses in the foundation course were one hundred feet long, three feet thick, and of various widths, and were placed lengthwise with the current. Three tiers of mattresses were laid at this time. In June a line of piling was driven through the dam and tilted mattresses were placed against it, but the pressure was so great (the head of water being about sixteen inches) that it broke down the piling, and both piles and mattresses were swept away. Piles were again driven across the bayou through the dam in two rows, twelve feet apart, which were

braced to each other with two-inch plank and piles, the butts of which rested on the horizontal mattresses. Tilted mattresses, twenty-six feet in width and two feet thick, were placed in position against the upper row. Three courses of mattresses each twenty-five feet in width were laid horizontally immediately above the tilted mattresses; then a second course of tilted mattresses was placed against the first course, and the dam was built out upon each bank about fifty feet with willows and stone.

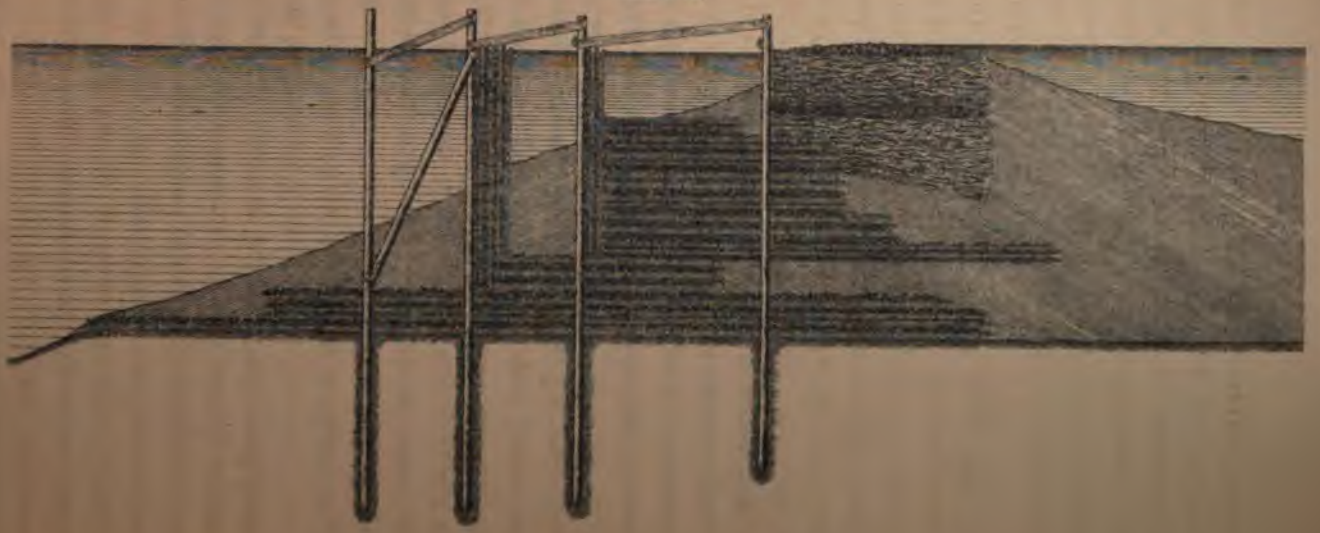
The work soon after showing a tendency to give away, third row of piles was driven twelve feet above the second and braced to it with plank. Two mattresses, each two hundred feet long, were tilted against this row, and the space between them and the shore was filled with willows and stone. These mattresses gradually dropped below the surface of the water, so that in January, 1877, the water over them was seven feet deep.

Examinations made on September 24th, showed a depth of eighteen feet over the mattresses. In December, 1877, the dam was again built to the surface of the water by placing eight tiers of mattresses above the upper row of piles, the foundation course being fifty-three feet wide and the top course fifteen feet. Previous to placing these mattresses, the greatest depth of water was twenty-three feet. In April, 1878, the dam, having settled again, so that there was a depth of five feet of water over it in the deepest place, was again built up above the surface of the water with loose willows and stone.

This work was twenty-five feet wide and five feet thick. The total number of mattresses in the dam was seventy-four; the total amount of willows three thousand eight hundred and eighty-eight cords; of stone, one thousand two hundred and fifty-eight cubic yards. During the construction of the dam the overfall caused a deep excavation below it, the depth

PLATE 14.

SECTION OF DAM AT GRAND BAYOU



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of water about fifty feet below the dam being fifty-seven feet.

The accidents, losses and delays in the construction of this work were due entirely to the absolute necessity for economy at the time the dam was constructed. A structure with a foundation two hundred feet wide instead of one hundred feet, with the entire work built of mattresses placed horizontally, would have been capable of resisting successfully the force that so severely tried it. The effect of the dam upon the bayou above it was to shoal it quite rapidly. In March, 1878, the maximum depth between the dam and the pass was 11.5 feet, where originally there was thirty-one feet. In the spring of 1879 there was so little depth that a steam launch drawing four feet could not enter the bayou. The indications are, that in a short time the deposit will reach the surface of the water; that the marsh grasses and reeds will cover the place where formerly there was a depth of water of over thirty feet, and that nothing will mark the location of the bayou except the scattered clumps of willows that grow along its former banks.

A section of this dam is shown on Plate 14.

CHAPTER XII.

DEVELOPMENT OF JETTY CHANNEL—TWENTY FEET CHANNEL OBTAINED—EFFECTS OF WING DAMS.

THE processes of construction described in detail in the preceding chapters, embrace nearly all the methods employed at the jetties and the head of the passes, except the works of consolidation.

The description of the works at the jetties and the history of the development of the channel were, at the close of Chapter VIII. brought down to June, 1876.

The channel continued to develop rapidly through the summer and early fall. A careful and detailed survey made on October 5th, showed a channel twenty feet deep, with a least width of two hundred feet, between the pass and the gulf. This survey was made by Mr. Eads's engineers. The government inspecting officer was not present, and no report announcing the obtaining of the channel was made to the Secretary of War.

It was the opinion of Gen. Comstock that it was necessary to obtain a channel through the shoal at the head of the pass twenty feet deep and two hundred feet wide before Mr. Eads could claim his first payment from the Government. As the latter held to the contrary opinion, and appealed from the decision of Gen. Comstock, the President appointed a commission to decide the question and report to the Secretary of War. The members of this commission were Gens. J. G. Barnard, H. G. Wright and B. S. Alexander.

In the letter given them by Secretary Cameron they were structed to give their opinion on the following questions:

First—"Is the shoal at the head of the South Pass a part f that pass, or of the main Mississippi River? and

Second—"If Mr. Eads obtains a channel twenty feet in lepth in the South Pass, exclusive of this shoal, is he entitled nder the law to his first payment of half a million dollars?"

They were also asked to give their opinion upon the depth and width of channel necessary to be secured through this shoal; to interpret the words "average flood tide" used in the act, as applied to the head of the pass; decide whether, in regard to permanency, the jetties were constructed according to the spirit of the act, and to present any general suggestions which they might consider necessary.

The commission arrived at Port Eads November 12th, 1876, and after making a careful examination made their report on the 19th.

They state in answer to the first question, "That this shoal is not exclusively a part of the South Pass, for it extends entirely across the river from shore to shore. It is therefore a shoal common to all three of the passes, but the channel (or channels) through this shoal, by which access has been had, or is to be had in future, from the river above into the South Pass, is a part of that pass."

They answer the second paragraph of this question in the affirmative, since the obligation of the United States Government to pay half a million dollars applies exclusively to the "wide and deep channel, between the South Pass of the Mississippi River and the Gulf of Mexico," since, in their opinion, the payments are not affected by the channel at the head of the pass, unless it should be delayed so long as to incur the forfeiture of the concession as stated in the act. They consider a channel twenty-six feet deep and two

hundred feet wide as sufficient for a permanent ch through the shoal at the head of the pass. The pla "average flood tide" should refer to the low water sta the river, since it is necessary that the full depth shou maintained through all seasons of the year. In regard t stability and permanency of the jetties, they consider th general plan they correspond substantially with that des by the Board of 1875, and that Mr. Eads has departed its detailed plans only as experience has shown to be r sary, and although a small amount of stone has been thus far, the jetties, they say, "except at their sea en deep water, where some damage has been done, have re without material injury the floods, storms and waves there has been more than a year's exposure, with its v and autumnal storms for some portions of the ex work." That while the jetties do not exhibit the "sub tial and permanent work" ultimately contemplated b law, they have been designed and constructed thus fa cording to its spirit. They offer the general suggestio the jetties, especially their sea ends, should be loaded heavily with stone and their consolidation hastened.

And they say further: "We are of the opinion that enlargement of section at the sea ends and consolid throughout by the application of stone should be under at once, and a reasonable progress therein be made the dition of the second and all future payments." To m compliance with this recommendation the condition of t payments would have been a direct infraction of the c concession, which left Mr. Eads entirely "untrammel the location, design and construction" of the works. recommendation caused him to write a letter of remonst to the President of the Commission, Gen. Barnard, in he stated in effect that he did not believe he would rec single payment on the work unaccompanied with some h

ation on his part or unjust condition. (For the detailed statements of the Board see Appendix 10.)

This report, with an extended discussion of the first two questions by Gen. Barnard in behalf of the Board, was referred to Attorney-General Taft for his legal opinion. His conclusions were as follows:

"1. That Mr. Eads and his associates are bound by the express terms of the said condition, on pain of forfeiture of their privileges, etc., to secure a navigable depth of twenty, twenty-two, twenty-four and twenty-six feet, within the periods prescribed, through the channel over the shoal at the head of the pass, and likewise over the bar at its mouth; that by necessary implication, they are also bound to secure a navigable width of the required depth in each instance through the channel at each of those points; and that the provisions in said condition, as to the depth and width, are the only ones of the kind which apply to said shoal.

"2. That the provisions in other parts of the statute requiring specific depths and widths, varying from twenty feet in depth by two hundred feet in width, to thirty feet in depth by three hundred and fifty feet in width, relate solely to the work at the mouth of the pass.

"3. That the payment of the first and other installments is controlled exclusively by the terms of the particular provisions authorizing such payments; and that since the specified depths and widths mentioned in these provisions have reference only to the work at the mouth of the pass, so soon as the depth and width required for any such payment are obtained, it may then be made, provided no forfeiture has been incurred under said condition.

"Accordingly, the answer I make to your question is, that the first installment of $500,000 can be made when the channel at the mouth of the pass is twenty feet deep and two hundred feet wide, although the same depth be not obtained

through the shoal at the head of the pass, if no forfeiture shall have arisen by action of Congress, or without action of Congress, as provided in the condition mentioned."

The deposit of soft mud, which usually occurs in the river bed during the low-water season, slightly reduced the depth and width of the channel through the jetties, so that there were several points where it was deficient. This contraction of the channel occurred before the inspecting officer made his survey. The three dipper dredges were brought from the head of the pass to enlarge the channel. Unfortunately it was necessary for them to perform considerable work at the sea end of the jetties, where they were almost constantly exposed to the waves, which made it dangerous and almost impossible to work dredges, that required to be anchored to the bottom by upright posts. Accidents, delays, and great expense were the results. It was not until December 27th that the channel was restored. On account of this delay and the discussion of the legal points at issue, payment was not made to Mr. Eads until the middle of February, 1877, although he was clearly entitled to it on October 5th, 1876. In consequence of this delay, and the want of necessary funds, very important works at the head of the passes were necessarily postponed, and afterward built at a high stage of the river, at a greatly increased expense and loss of time.

During the interest and excitement attendant upon the attempts to secure the twenty feet channel, an event occurred, which cast a gloom over the whole work. This was the sudden death, by heart disease, of Mr. Bayley, Resident Engineer, on December 14th, 1876, at the age of fifty-five years. His active and useful life deserves a more extended sketch than is appropriate here. As a civil engineer, engaged in the location and construction of levees and railroads; as a state legislator and a member of the New Orleans Board of Health; as a writer on subjects of interest and benefit to

his fellow-citizens; in all these capacities he exhibited a great interest, sound judgment, and a devotion to the best interests of his fellow-men. His long experience and exhaustive studies in the hydraulics of the Mississippi River, brought to the question of deepening the mouth of the river a most valuable assistance. During the inception of the jetty enterprise, his able articles in the public press and his letters to members of Congress, ably written, with strong arguments and facts clearly put, had great influence in the selection of the jetty plan for the improvement.

When the construction of the jetties commenced, his counsel both in regard to general methods and the details of the work were invaluable. He was most intensely interested in the success of the jetties, on which he had publicly staked his reputation as an engineer. Mr. Eads cherished for him a most affectionate regard, and the highest respect as an engineer, and he spoke the sentiments of all Mr. Bayley's associates on the works, when, on being presented with the certificate of the United States Inspecting Officer, stating that a channel twenty feet deep and two hundred feet wide existed, he said, "My only regret is that Mr. Bayley could not have lived to share in our glorious success."

Soon after the death of Mr. Bayley, Mr. Corthell was promoted to the position of Resident Engineer, and Mr. Schmidt to that of Chief Assistant Engineer.

In the following year the construction work at the jetties consisted mainly in raising them by mattress and willow work; by consolidating them, especially near the sea ends with large quantities of stone, and by the construction of wing dams for confining the current. The mattress work over the whole line of jetties had become considerably compressed by its own weight and that of the sediment lodged in it, and the rock placed upon it. In many places the subsidence had become so great that the depth of water flowing

over the jetty was from two to three feet. The mattre were generally, however, so near the surface of the w that it was impossible to float another tier over them. ' ous plans were resorted to for raising the jetties above surface of the water.

First.—By building mattresses upon the ways on sl towing them to their location, and then at high tide means of a steam pile-driver, raising one side of the mat and forcing it to its place against the guide piling.

Second.—By building mattresses on ways, constructe a decked barge. These ways, about one hundred and feet in length, were built of round pine piles spaced six apart on the deck of the barge, and at right angles with edge on which they rested, and which they overhung a twenty-five feet, and to which each pile was hinged. butts of the piles were firmly fastened together. The tress, often one hundred and fifty feet in length, twenty feet in width, and two feet thick, was built on these w The barge was then towed to the place required; a latch secured the butts of the piles to the deck of the barge "let go;" the overhanging ends dropped suddenly on jetty, and the mattress was thus launched to its place. barge was then pulled away by the tug, the piles drawing from under the mattress. The butts were latched down a and the barge was towed to Port Eads for another mattre

Third.—By building mattress work in place on the jet This was done by first cutting hickory pins in lengths to the irregularities of the top of the jetty, and inserting them the cross-binders of the old mattresses. The willows then placed between the pins in the same manner as w built on the ways. Several thousand lineal feet of the je were raised in this manner, and well loaded with ru stone.

Fourth.—By building mattresses on skids laid across

ing timbers, which were fastened to the river and sea rows of piles. This kind of construction was adopted for raising the end of the east jetty, which had settled from five to nine feet below the surface of the water. When two or three hundred lineal feet of mattress work had been constructed on these skids, the latter were pulled out by the tug; the mattress dropped into the water, on which, while floating, were built other courses, until the weight was sufficient to ground the mass upon the submerged jetty. It was then securely held in place by large quantities of stone.

The wing dams that had been previously constructed on both jetties at Stations 100, 112 and 118 were raised to the surface of the water by mattresses laid horizontally. A special construction was adopted for those at Station 118, by which a broad base and a slope seaward were obtained.

In all places exposed to the violence of the waves, where the top tier of mattress work was liable to be thrown off from the jetty during storms, the mattresses were generally firmly secured in place by a row of piles, driven close against them on the river side, and often by a new row of piles on the sea side, wherever a pile-driver scow could be floated. Near the ends of both jetties the mattress work was still more firmly secured by heavy timbers placed across the jetties and bolted to the piling.

Many new wing dams were constructed, the space between the river ends of two opposite wing dams being generally about six hundred and fifty feet, though at some points less than six hundred feet. On the 24th of July, 1877, twenty-nine wing dams in all had been built. Some extraordinary effects on the channel were produced by these structures, which we will describe more in detail.

On account of the wide expanse above the head of the west jetty, the current produced but little effect upon the hard clayey bed. The width between the east jetty and the

west shore line varied from fourteen hundred feet at Station 26 to sixteen hundred feet at Station 40. In order to concentrate the flow of water over this space, wing dams were built in pairs at Stations 26, 30, 35 and 38 from the east jetty and from the west shore. Those built from the west shore extended into the channel about one hundred and fifty feet beyond the line of the west jetty. They narrowed the waterway to about five hundred and seventy feet. This work was done in the fall and winter of 1876. During the flood season of the following spring the effect of these wing dams was as follows: The channel from Station 26 to Station 40 improved rapidly, but the more marked effect of this concentration was seen below the head of the west jetty, where there had been no confinement of the waterway, and the channel was nearly nine hundred feet wide. In April the maximum depth in the channel was thirty-three feet; on May 25th, it had increased to seventy-five feet, and a remarkable enlargement laterally had taken place. On July 5th the depth was ninety-five feet and the width of the basin thus formed was nearly eight hundred feet.

In order to investigate the causes of this peculiar phenomenon, float lines were run on June 26th from Station 26 to Station 66. The river at the time was at the flood stage of that year, the reading on the Carrollton gauge being about eleven feet.

Slope observations were made at the same time between East Point and Station 60. These were made by noting the surface of the water on gauges set at various points on the east jetty by careful leveling. These readings indicated that between East Point and Station 30 the fall per mile of the surface of the water was about four inches, between Station 30 and Station 37 eighteen inches per mile, while from Station 37 to Station 60 the surface was nearly level. The results of float observations agreed very closely with the slope

The average velocity of the central thread of the current from Station 30 to 50 was nearly three hundred feet per minute; beyond that point the force of the current was entirely broken. The floats moved in nearly parallel lines from Station 30 to Station 40, from which point they converged rapidly, until at Station 50 the greatest width between two floats was not over one hundred and thirty feet, except those that were caught by the strong eddies that existed on either side of the straight current, and were often moved quite rapidly up stream, the eddy giving them a circular direction, drawing them into the straight current several hundred feet above their point of departure from it.

These strong eddies and the vortices caused by them were plainly seen, and the line of demarkation between them and the straight current was very distinct to the eye.

The effect of these wing dams was, in accordance with the established principles of the "*vena contracta*," the contracted vein, of Newton, and very clearly illustrates those principles on a large scale. It also illustrates the extraordinary force of an eddy current; for although the velocity of the current in these eddies was not in some instances over thirty feet per minute, yet on account of its circular motion it widened this great basin rapidly, until encroaching upon the west jetty it undermined the foundation of the mattresses and caused a crevasse to break through the solid wall of the jetty about one hundred and fifty feet wide, with a central depth of thirty feet on the sunken mattresses. This crevasse being caused by an eddy current, and not by a head of water, extended but a short distance beyond the jetty and was easily closed by mattress work. Using the elements as we found them, namely the mean velocity, volume, and the width of the straight current, we find by calculation, that a depth of ninety-five feet should have existed, and this was the maximum depth observed. The river floods subsided in August.

and during the fall a deposit took place in the deepest part of the basin, decreasing the depth to about seventy-five feet. This deposit, however, was very soft, the sounding lead sinking into it several feet.

During the flood season of 1878 the material deposited in the basin was quickly removed; the eddies on either side became stronger even than they were during the previous year; the straight current was brought into still narrower limits, and a depth of one hundred and fourteen feet was reached. The effect of this great disturbance upon the channel was very injurious, heavy deposits of sand being made at various points from Station 80 to the crest of the bar. The object for which the wing dams were built having been obtained, namely, the deepening of the channel opposite them, they were removed back to the line of the west jetty—thus increasing the width of the channel one hundred and fifty feet above Station 40, and remedying the evil.

This basin gave an opportunity to investigate the question of the stratification of the material comprising this portion of the bar. An instrument was made, weighing about eighty-five pounds, which had a sharp steel point for penetrating the material at the bottom, when dropped from the launch. This point was fitted into a two and one-half inch gas pipe, about eight inches long. In the side of the point was an opening about two inches square with a projecting lip on the lower edge to catch the material when the sounder was drawn up. This short piece of gas pipe was screwed into another piece about two feet long, so that when the cavity was filled the point could be unscrewed from the longer piece and the material removed. A mass of lead was run about the gas pipe to give it weight sufficient to strike the bottom with great force. To hold the point downward while falling, a white pine post about two and one-half feet long was fitted into the gas pipe and secured to it firmly by side straps of

iron. A ring with a half-inch rope attached was fastened in the end of the post and the machine was dropped from the side of the launch, the rope running through a sheave, set in a post about five feet above the rail. The material brought from the different localities and depths was dried, then pounded up, if clay, and sprinkled on gummed paper. A survey was made at the time of making these observations. The chart of this survey when compared with previous charts gave the data for making a sketch showing the line of demarkation between original material and that on any areas over which shoaling may have taken place since the jetties were commenced, and on which new deposits must have been made. On the sketch the points from which the specimens were taken were located and noted according to whether the material was clay, sand, mud, half clay, or half sand. On this chart a characteristic curve was drawn at twenty-six feet depth, as the line between clay and sand seemed to be approximately near this level. A record which was kept of the depth at which each kind of material was met by a dipper dredge working at Station 22, shows that the line between sand and clay at that locality is at about twenty-eight feet depth.

The size of the sand particles, as ascertained by the sediment observations of Captain Brown, United States Engineers, varies from one-one thousandth of an inch to one-fiftieth of an inch in its largest daimeter, the latter size being very rare. It is really a fine mineral silt with a small admixture of alumina.

The pockets of clay, so called, are no doubt very similar to the material found in the "mud-lumps," which, according to a careful analysis made by Captain Brown, is composed of the following ingredients:

Silica	58.00	parts.
Alumina	29.67	"
Lime and its Salts	5.34	"
Magnesia	3.50	"
Iron and its Salts	2.46	"
Common Salt	1.00	"
Total	99.97	

The hardness and supporting power of the material the surface to twenty feet depth, is seen from the reco the piles driven on the line of the jetties.

The average results are as follows:

Weight of hammer	3000 pound
Its average fall	19½ feet.
Average number of blows	80
Average depth driven	19½ feet.
Average distance driven at last blow	¾ of an i

This is the record of the piles driven along the w length of the west jetty; and the record of those drive the east jetty show nearly the same character of material

CHAPTER XIII.

FINANCIAL EMBARRASSMENTS—DESCRIPTION OF THE DREDGE-BOAT G. W. R. BAYLEY—TWENTY-TWO FEET CHANNEL SECURED—REPORT OF COMMISSION—CONGRESSIONAL ACTION.

THE financial embarrassments with which the work was hampered during the spring and summer of 1877, not only rendered its further prosecution difficult, but its completion doubtful, in the minds of the majority of those interested in it. The amount of construction work done and its great cost was far beyond what the concurrent channel results indicated. The five hundred thousand dollars received from the government in February had all gone to pay pressing indebtedness, and to meet obligations and claims that could no longer be put off. It was necessary again and again, month after month, to renew notes and extend the time of payment for bills of material. Arguments, and appeals even, were often necessary to obtain the renewal of favors already granted so many times.

The fickle channel at the sea end of the jetties made these financial labors still more arduous, and their result more and more uncertain. It was a very discouraging period in the history of the enterprise. The most strenuous exertions had been put forth by Messrs. Eads and Andrews to raise the necessary means to meet the pay rolls and incidental expenses, but now every available source was exhausted; the pay rolls were two months overdue, while the construction of very extensive and expensive work, at the head of the passes

especially, was imperatively necessary not only to obtain the required channel into the pass, but more important still, to restore to it the volume necessary for the more rapid development of the jetty channel.

The financial depression at last became so great, that Messrs. Eads and Andrews, who had gone north for the purpose of making the necessary arrangements for money to carry on the work, telegraphed Mr. Corthell, the Resident Engineer, on August 7th, as follows: "Discharge the whole force except those necessary to protect property, unless they are willing to work for certificates, payable on receipt of the twenty-two feet payment." All the employees were immediately summoned to appear at the office; the situation was briefly explained to them, and without any attempt at persuasion, those who were willing to remain on the conditions named were asked to come forward and sign an agreement to that effect. It was a gratifying proof of confidence in the work on the part of these men, that only two out of the seventy-six refused to accept the terms. The fairness with which they had been treated; the promptness with which, until now, they had received their monthly pay; the evidence of final success, which they saw in the steadily improving channel, and in the constant sight that daily met their eyes in the rush and whirl of the swift waters, as they cut their way through the sand and clay to the deep water of the gulf, and more than all, the interest in and devotion to the work on which they had been so long engaged; all these reasons made them nearly unanimous in their resolve to remain.

The scene that was witnessed at Port Eads on that sultry afternoon in August, was extremely interesting and exciting. Little did the great valley realize that its vast commercial interests were being advanced by a few laboring men at the mouth of the Mississippi River, to whom great credit should

en for the devotion to duty and faith in the ultimate
s of the jetties exhibited by them in the calm and
ined spirit with which they came up and signed that
:t.

ɔugh the jetties were generally raised to the height of
) flood tide, they were by no means impervious to the
water. Through the openings of the mattresses the
water forced a strong current. Float observations
that at least thirty per cent. of the volume passing
Point" was lost through and over the mattress work
:eaching the sea end of the jetties. It was evident
secure the full benefit of the confined current, the
ces of the mattresses must be closed by the consolida-
the works, but more especially by inducing the river
sit or bank up its sediment along the slope of the jet-
'he latter result was slowly, but very effectually ob-
ɔy the wing dams. They did not stop the entire flow
urrent; they simply checked it, turning the larger part
jetty channel and passing the remainder with the
ıt in suspension through the meshes of the tilted
ses with a feeble current, which, unable to hold up
ɔended matters, dropped them behind the dams and
he jetties. This process, carried on continually
the period of high river, slowly built a batture or
ainst the river side of the jetties, rising higher and
until in many places the surface of the water was

ame effect was seen on the sea side of the jetties as
ard as Station 80 on the east jetty and Station 95 on
; jetty. Each season showed new deposits of this
d every cubic foot of material thus deposited against
es helped to hold back in the channel, for its devel-
the waters that otherwise would have escaped and
useless.

By the 30th of July, while no increase of depth was seen on the outer bar, the channel had improved so much that twenty-two feet in depth by two hundred feet in width could be carried from "East Point" to Station 105, or ninety per cent. of the whole distance through the bar. The least width of the twenty-one feet channel was two hundred and fifteen feet, and only four thousand cubic yards of material remained in the way of a channel twenty-two feet by two hundred feet. Hoping to remove this obstruction by the ordinary means, Kimball's dipper dredge, on September 22d, was fitted up and set at work at the sea end of the jetties (where nearly all the work was to be done) with good prospects of success at first, but, stormy weather intervening, the sea became too rough for a dredge of this kind, and after several weeks of unavailing efforts to work against the elements, the attempt was abandoned.

To meet such an emergency as this, and to provide for the future maintenance of the channel, Mr. Eads constructed a dredge boat, which in general plan and in most of its details was his own invention, and which combined all the requisites demanded of a dredge compelled to work in deep water, in a strong current and in the sea-way often found at the end of the jetties. It was evident that for some time to come, at least until the final development of the channel, two conditions were at any time liable to arise to require a change to be made in the channel by artificial means.

First.—A channel much deeper than required but too narrow.

Second.—A channel of greater width than was necessary but of too little depth.

In other words the current might recover the full section required for its wants, but such a section might not conform to the exact dimensions in depth and width demanded by the legal and arbitrary specifications of a Congressional enact-

o that, without some means of increasing slightly the
nd width at certain points, although a few yards only
rial should need to be removed, the payments both
ining and maintaining the channel might be delayed
ths as they had been in this case. There is no doubt
the 20th of September, two days' work by a suitable
would have secured the twenty-two feet channel.
ew dredge-boat constructed at Pittsburg, Pa., by D.
Carroll & Co., and named "*G. W. R. Bayley*," ar-
Port Eads November 15, 1877. After some delays
g necessary alterations, she commenced work on the

ar conditions which exist at the mouth of the jetties,
alluded to, render the use of a dredge-boat which
t the waves a necessity—the ordinary dredge-boat
still water would be almost useless for the purpose.
r this reason that the dredge-boats *Macalester* and
were designed.
boats had been for several years in operation in
st Pass and Pass à Loutre. They operate by having
eller arranged to be lowered below the line of the
ere it stirs up the mud and sand, and the current
propeller is thrown against a sheet iron shield,
uses it to rise to the surface of the water, charged
deposit from the bottom.
eory upon which they work is based on the assump-
the current will carry to sea the sediment which is
p into it. The theory upon which Mr. Eads based
at the mouth of the South Pass is founded on the
ion that rivers flowing over deposits of silt, which
they have made themselves, are continually charged
uantity of sediment proportional to the velocity of
m. Hence, if the water be already charged with its
quantity of sediment, any additional amount thrown

up into the stream will quickly fall to the bottom again, and therefore dredges operating on the plan of the *Essayons* and *Macadester* can only deepen a bar of any considerable length by repeatedly throwing up near the surface of the stream the sediment which the propeller disintegrates at the bottom. This principle was well illustrated by the fact that the dredge-boats were only operated during the ebb-tide, when the current is the strongest, and when it has not had time to gather up from the bottom the additional quantity of sediment which it is then capable of supporting in suspension. It was to be expected, therefore, that the plan of the *Bayley* would be entirely different in principle from that of the government dredge-boats.

In the case of the *Bayley*, the water is made the vehicle of transporting the deposit from the bottom of the river through a large suction pipe and a powerful centrifugal pump, into capacious tanks built in the body of the boat, which transports the dredged material to back of the wing dams or out to the deep water in front of the bar, where it is discharged through the bottom of the tanks.

The principal obstacle which has interfered with the successful pumping of sand or silt from the beds of streams, has arisen from the difficulty of proportioning the quantity of solid matter to the volume and velocity of the stream which is made to transport it. A given volume and velocity of water through the suction-pipe is capable of sustaining in suspension a definite amount of solid matter. If too great an amount of solid matter be admitted into the suction-pipe, the stream is unable to transport the excess; the pipe becomes clogged, and the pump ceases to throw either water or sand.

To remedy this difficulty, the end of the suction-pipe which rests upon the bottom of the river is curved into the form of a flat scraper, four feet in width, which is armed with

a steel plate, forming a bit, which may be fairly compared to the bit in a carpenter's plane. To prevent this bit from making too deep a cut in the sand, the end of the pipe is supported on a horizontal plate, which rests upon the sand in advance of the bit or scraper. To insure the proper quantity of water in the suction-pipe with the sand, the horizontal plate just described forms the bottom of a water chamber, into which the water is admitted from above on both sides of the pipe. This water is drawn into the suction-pipe through a narrow opening as wide as the scraper. The end of the suction-pipe, therefore, is continually scooping in a stream of sand four feet wide, and a stream of water of the same width, immediately above the sand. The cut made in the sand is eight or ten inches deep. The water enters about three inches in depth of stream, and the sand, which is passing in over the top of the scraper, is therefore kept fluid by the water. The scraper is designed to be moved at a speed of from ten thousand to fifteen thousand feet per hour.

The centrifugal pump in the *Bayley* is the largest one of the kind ever constructed in the United States, and is known as the Andrews Cataract Pump. It was built by Mr. Joseph Edwards, 14 Water Street, New York, on the patent of Wm. D. Andrews, and is of the same character as the two which furnished the magnificent cataract, which our readers will remember to have seen at the Centennial. The one in the *Bayley* is twice the capacity of the two referred to, combined. The fan is six feet in diameter, and three feet wide. This is driven by an eight-inch steel shaft, actuated by two engines, each twenty inches stroke, and twenty-four inches diameter of cylinder. The steam is supplied by four four-flued steel boilers, each twenty-six feet long, and forty-two inches in diameter. The pressure allowed upon them by the United States inspecting officer was fixed at one hundred and fifty-nine pounds per square inch. The working pressure is, how-

ever, limited by Mr. Eads to one hundred and twenty-five pounds, to insure additional safety. All the engines exhaust their steam into a large surface condenser, in which a twenty-six inch vacuum is maintained. The boilers are placed forward of the tanks, in the hold of the boat.

The suction-pipe is twenty-seven inches in diameter, of one-quarter inch wrought iron. It is attached to the hull of the boat, in a recess four feet wide, which extends from the stern twenty-five feet forward. It joins the boat immediately above the bottom, and is attached to it by a universal joint of peculiar construction, not being hemispherical. The ball and socket joint for pipe of such size, with the lateral and vertical movements to which it would be subjected, became so unwieldy in size as to necessitate the present novel device, which is the subject of one of Mr. Eads's patents on the boat. This joint admits of a motion of the pipe of sixty degrees in any direction; that is, thirty degrees from the line of the axis when straight, without the area of the pipe in the joint being reduced by this deflection.

The working position of the suction-pipe for twenty-six feet of water, is an angle of about thirty-five degrees from the horizontal. When the dredging ceases, the end of the suction-pipe is raised up above water, and securely housed under a fan-tail extension of the main deck of the boat, which projects some fifteen feet beyond the stern-post. The discharge pipe is thirty inches in diameter.

The pump stands just forward of the universal joint; the center of the shaft is exactly four feet above the boat's bottom, and the engines which turn the shaft stand about eight feet forward of the pump. A few feet forward of these engines the tanks commence. These are sixty feet long and nineteen feet wide, and the tops of them are twelve feet above the main deck of the boat, the boat having ten feet depth of hold, and thirty-two feet beam.

The tanks are divided into four compartments, each of which terminates in a hopper at the bottom, having an opening four feet in diameter through the bottom of the boat. These openings are closed by valves of similar diameter, having a vertical rise and fall of thirteen inches. Each valve is suspended by a single rod in its center, which is attached to a hydraulic jack, six inches in diameter, firmly secured in the upper portion of the tank on a strong oak timber. The power of the jack is regulated to twelve and one-half tons, which insures close fitting of the valves. The jacks are exceedingly simple in construction, and are all four supplied by a hydraulic ram, which is a modification of the Cameron pump, first designed by Mr. Eads in the construction of the St. Louis bridge. The steam piston of the ram is seven inches in diameter, while the plungers are but two inches, and are simply extensions of the piston-rod, running into a strong horizontal pump-chamber, at each end of the steam cylinder. By this arrangement, a constant pressure of about one thousand pounds to the square inch is always ready to be used in closing the valves of the tanks. The ram being automatic, remains at rest with the steam pressure upon it, until one of the valves is opened at either one of the hydraulic jacks, when it immediately supplies the quantity of water needed in the jack. To facilitate the discharge of the sand from the tanks, a powerful Cameron pump is placed on board, the suction-pipe of which is nine inches, and the discharge pipe six inches in diameter. This supplies two jets, of one and one-quarter inches diameter, near the bottom in each hopper.

It is sometimes desirable to discharge the dredged material from the centrifugal pump, not into the tanks, but on either side of and at a distance from the boat. For this purpose two discharge pipes are provided, one on each side of the boat, which can be swung out from it by means of a der-

rick, and through which the sediment may be carried and discharged from the side of the boat. The discharge pipe of the pump is arranged so as to connect, by a curved joint of pipe, with either of these outside discharge pipes, or with the central pipe leading into the tank. The boat is built entirely of iron, and is considered a very superior job. It is about two hundred feet in length over all, and is propelled by two horizontal engines, each seven feet stroke, and twenty-one inches diameter, turning wrought iron shafts with wrought iron wheels, twenty-five feet in diameter. The paddles are of wood, eleven feet long, and fourteen inches wide. The boat is surrounded by an iron bulwark, about thirty inches high, set back five and a half feet from the side of the hull. The tanks have an estimated capacity of six hundred and fifty tons of dredged material and water. Two overflow gates are provided for the tanks, which allow the water to escape when they are filled to the overflow level, the sediment settling to the bottom. The pump raises one hundred and thirty tons of water per minute, twelve feet high. The boat draws about five feet, with coal on board ready for work. The engines were non-condensing engines at first, and those that drove the pump had oscillating cylinders, twenty by twenty inches. These were defective, and were exchanged after the first year for the present ones, and condensing apparatus was added. Since these alterations the boat has given entire satisfaction. Her total cost was a little over one hundred and fifty thousand dollars.

To avoid turning the boat at the end of each trip, she is provided with a rudder at the bow, and one on each of the two parts of the hull at the stern, where it is divided, to enable the suction-pipe to be housed. The dredging is done by moving the boat through the channel, down stream, at about two and one-half miles per hour, with the scraper down. As soon as the tanks are filled the scraper is raised,

and the boat proceeds with her load to the place chosen for dumping it. About two-thirds of the time is lost in dumping and returning to position. The tanks are usually filled in from six to eight minutes, about one-half the contents being dredged material. In sand, she will easily excavate in this way three thousand five hundred cubic yards in ten hours, and in mud five thousand cubic yards. If steadily pumping and discharging the material overboard, without going with her burden to dump it elsewhere, she raises it at the rate of ten thousand five hundred cubic yards of sand, or fifteen thousand cubic yards of mud, in ten hours.

The *Bayley* is especially adapted for her peculiar work, and is superior to the powerful dredges used on the Clyde, at Glasgow, for a similar purpose, and under somewhat similar conditions, and which have been considered the best in the world. They have an endless belt, on which are a great number of buckets or scoops, which, passing through a recess in the hull of the boat, dig into the bed of the river, bring up the material, and discharge it into tanks. Their maximum performance in good material, in ten hours work, is about twelve hundred cubic yards.

A survey, made on the 15th of December, showed that a channel twenty-two feet deep, and more than two hundred feet in width, existed from the deeper water in South Pass, to the deeper water in the gulf.

The certificate of Captain Brown was given on the 17th, to confirm which, and to decide certain questions for the Secretary of War, a commission composed of Gens. J. G. Barnard and H. G. Wright were instructed to proceed to Port Eads to make the necessary examinations, and answer the following interrogatories.

First.—"What depth and width of channel have been secured through the South Pass of the Mississippi River, to deeper water of the Gulf of Mexico?"

Second.—"Has such depth and width of channel been obtained by the action of such jetties and auxiliary works, as are contemplated by the terms of the act of Congress aforesaid?"

Third.—"Are the jetties and auxiliary works constructed, or in process of construction, permanent, sufficient, and thoroughly substantial, within the meaning of said act of Congress?"

Fourth.—"Have the conditions prescribed in said act of Congress been fully complied with by said James B. Eads, in so far as he has proceeded with the work?"

Fifth.—"Is James B. Eads, in your opinion, entitled to receive the five hundred thousand dollars, which, by the terms of said act, was to be paid him, when, having fully complied with the conditions prescribed by said act, a channel twenty-two feet in depth, and two hundred feet in width, shall have been obtained by the action of said jetties and auxiliary works?"

In their report, dated Port Eads, January 5th, 1878, made after carefully examining the works and directing a survey, they confirm the statement of Captain Brown, and further state in answer to the first interrogatory, that the twenty-two feet channel at the jetties, between the South Pass and the Gulf of Mexico, varies from two hundred feet in width to more than five hundred feet, and that a practicable channel of 22.4 feet exists through the whole extent of this portion of the pass; that at the head of the pass a channel two hundred and sixty-four feet wide and twenty-two feet deep exists, with a practicable channel of twenty-three feet, and that in the main body of the pass no material changes have occurred since the survey of the United States Coast Survey, in 1875, which statement conflicts with that made the previous year by Major Howell. In answer to the second interrogatory, they discuss the question of dredging as an auxiliary. They

er to the report of Humphreys and Abbot, and to the re-
t of the Board of 1874, in both of which dredging is
ommended, as a necessary accessory to jetties. The act
ler which the jetties were constructed clearly intends that
ies and auxiliary works shall be the *effectual* agents in ob-
ing the "wide and deep channel," but at the same time
ws of dredging as a legitimate auxiliary, and they say:
we look at the actual facts presented by the prosecution
his work, we find that where two and a half years ago
e was a bar at the mouth of the South Pass of over two
s in extent, measured from twenty-two feet of water in-
to the same depth outside, over about half a mile of which
e was but eight feet of water, a 'wide and deep chan-
of twenty-two feet depth now exists, and a result inferior
hysical magnitude but no less in importance at the head
he passes has been obtained. And these results are so
usively due to the 'jetties and auxiliary works,' that the
iliary aid of 'appliances,' if in such we include dredging
hines, is utterly insignificant, consisting mainly indeed in
ght widening at two points and widening and deepening
third. By the erosion of the current, due entirely to
jetties and their fixed auxiliaries, about two and one-half
ions of cubic yards of bottom material have been re-
ed, leaving in its place the 'wide and deep channel.' Of
amount one million of cubic yards have been removed
he same agency since the twenty feet depth on the bar
obtained. By the action of the dredge-boats (see Capt.
wn's recent report to the honorable Secretary of War),
m twelve to twenty-eight thousand cubic yards have nominally
n removed by dredging. But it cannot positively be as-
ed that to the creation of the channel now existing even
insignificant amount has been contributed by dredging.
* * We have discussed the point of dredging at much
gth, because we conceive it to be the real one involved in

the third interrogatory; and we conclude by answering that, according to the construction above given, the depth and width of channel has been obtained by the action of such jetties and auxiliary works as are contemplated by the terms of the act of Congress."

Upon the question of permanency, embodied in the third interrogatory, they refer to the report of the Board of 1876, and state that as far as the works have been constructed, they are of such a character as to be both substantial and permanent when completed according to the design. They answer the fourth and fifth interrogatories in the affirmative, after which they submit some general views and recommendations, mostly referring to the sea-end of the jetties, which will be alluded to in a subsequent chapter.

During the winter and spring the construction work consisted mainly in consolidating the jetties with rubble stone, in building up the low places with loose willows, and in maintaining the wing dams. The progress of the channel development can be traced in the tables in Appendices 6 and 7, and by the cross-sections and profile of the bar on Plates No. 20 and 21. (Facing page 212)

It became very evident that the maximum depth and width of channel prescribed by the act of Congress could not be obtained with safety either to the pass or the jetties. The specifications were drawn up for the Southwest Pass, and were in every way applicable to it, but in regard to the South Pass they were in some respects very severe and entirely unnecessary.

On May 7th, 1878, Mr. Eads submitted a statement to the Secretary of War relative to the amount of work executed by him, and asked that certain modifications be made in the conditions imposed by the act. The grounds on which this request was based were as follows:

First.—The proportion of the entire outlay necessarily ex-

pended to secure the present depth had greatly exceeded all expectations; and

Second.—A necessity for relief in the times of the payments on account of serious financial difficulties under which he was laboring, and without which relief he could not further prosecute the work.

He estimated that he had completed at least eighty per cent. of the entire work, and stated that he had received thus far only $1,000,000. He asked for a modification in the manner of the payments and also in the widths of the channel.

In his argument he alluded to the fact that he undertook the construction and maintenance of the work for $692,110 less than the official estimate of the Commission upon whose report the act was passed. He had assumed the whole risk of their failure in the face of the predictions of official and other experts that they would be unsuccessful, and had taken all the risk of their destruction by storms and other causes—dangers believed by many to be insurmountable. He had not been permitted to improve the pass of his choice, with its normal depth of fifteen feet, but had been given one only one-quarter as large, with but eight feet depth. In spite of natural difficulties and unusual financial prostration, he had carried the enterprise to a point where its complete success was acknowledged even by its opponents. He had changed the little pass into a grand channel of commerce sufficient for the largest shipping that visits the port of New Orleans. He says further: "We ask no increase in the price of the work, nor do we ask to be relieved of the obligations to create a permanent channel thirty feet deep through the jetties, and that shall be fully as wide as the size of the pass will justify. We ask no legislation to retrieve forfeited privileges or lapsed concessions, nor the assumption of any risk of outlay for doubtful benfits. We ask simply that a reasonable portion of moneys actually expended may be repaid to relieve embar-

rassments resulting from provisions in the law unusually severe and oppressive, and which cannot now be retained without injuriously reacting upon the commercial and industrial interests of the country. We have striven to carry through, by private means and individual hazard, the largest and most important public work ever undertaken by the government; and have forborne, under many discouragements, to ask relief from the stringent conditions of the law until the official reports of the most eminent engineers of the government have confirmed the public faith in our complete success; and now that sheer necessity compels us to do so, we only come after the changing tides of commerce attest the substantial benefits already reached, and after the people are assured that private enterprise and courage have promptly secured, at moderate cost, 'an open river mouth,' for the Mississippi, in lieu of the more costly and dilatory method proposed of a canal with locks. And with this record we ask no payments on the work that will not leave in the hands of the government an ample amount of our compensation to insure the entire completion of the jetties." (For the full text of this letter, see Appendix 12.) This communication of Mr. Eads was referred for examination and report to Gens. Barnard and Wright. They did not agree with him in his statement that eighty per cent. of the work was completed, but they said: "We, as members of the Commission of 1876, and as ourselves constituting the Commission of 1877, have expressed our opinion that the work is being constructed according to the spirit of the act." * * * "We believe, moreover, that the work is now so far advanced and its success so far pronounced, that it is for the interest of the government and the country, not only to have the construction carried on, but pushed with the utmost possible vigor to such a point at least as shall insure their security and utmost efficiency of action in increasing the capacity of the channel."

* * * The depths and widths specified as desired by the petitioner will fulfill measurably the needs of commerce. * * * A draft of twenty-three feet (and it must be borne in mind that at the mouths of the Mississippi nearly all the depth on the bar can be realized in actual draft) will include probably eighty-five per cent. of the sea-going vessels of the world; while over the bar of New York harbor twenty-six feet is about the maximum for regular traffic, and twenty-eight feet (and a small fraction) the maximum ever carried over (the case of a war vessel, the Spanish *Numancia*, we believe)." See Appendix 12.

Congress was not willing, without further investigation and report by the engineers of the government, to fully comply with this request of Mr. Eads, but showed its confidence in his integrity and in his ability to complete the work, by voting at once an appropriation for him, of one million dollars; (five hundred thousand dollars of which was to be expended on the work), and by authorizing the President to appoint a Commission to report on the progress and probable cost of completion of the works, on the results produced and likely to be produced, their permanency, and the advisability of a change in the terms of the contract, in regard to the depths, widths, and payments.

During this discussion in Congress, General Humphreys, Chief of Engineers, U. S. A., in a letter addressed to Hon. E. W. Robertson, Chairman House Committee on levees and improvement of the Mississippi River, made another attack on the jetties, under the pretext of opposing the passage of a bill authorizing the appointment of the Mississippi River Improvement Commission, of which he claimed Mr. Eads was to be made president. As he alleges, the reason for such an extraordinary course on the part of Congress was the success claimed to have been achieved by Mr. Eads at the South Pass, he endeavors to prove that the jetties are a

failure. He states that the bar beyond the jetties has advanced, but not as rapidly as he had predicted, on account of crevasses, and of the low stage of the river at the flood during the previous three years; that "the usual flood reading of the river *at Carrollton is above fifteen feet;*" that in 1876 its highest point was only 12.7 feet, and that "the broad, thick sheet of earthy matter moving along the bottom of the passes" during flood river, was not present in any considerable quantity during those years.—(The foundation of this argument is destroyed by correcting his statement of facts. The records show the following: The average of high water marks on the Carrollton gauge for eight years, from 1872 to 1879, was 12.26 feet. The only crevasses of importance since that of Cubits gap, in 1863, was Bonnet Carrè crevasse, in 1874, and the average of the high water marks for the two years *previous* was 12.44 feet.)

He states that the favorable report of Captain Brown, in reference to the advance seaward of the bar, was made in December, 1877, immediately after a new and powerful dredge, designed to work on the newly-grown bar seaward of the jetties, had been employed for a month. After giving an historical summary of the jetties and their results, he emphasizes the following statement: "*The foregoing historical summary sufficiently proves that the results actually attained at the South Pass disprove the views advanced by Mr. Eads, and confirm those of the engineer department. Hence, any claim that he should be intrusted with the control of the Mississippi River, in so far as it rests upon the results thus far achieved by him, has no proper basis.*" (For the text of this letter, see Appendix 13.)

This extraordinary letter of General Humphreys was reviewed by Mr. Eads, in a letter addressed to Hon. Mr. Robertson. He states that the only bill reported in the House provides, that three of the five engineers shall be taken from the army, and that one of these three shall be president of

the Commission. He quotes from reports of Captain Brown to show that no such advance of the bar has taken place as is stated by Gen. Humphreys, but that, on the other hand, in the report of August 1st, 1877, in which Gen. Humphreys claims to find the proofs of his statement, the following language occurs: "Averaging, the twenty feet curve has receded about two hundred feet; the thirty feet curve about three hundred feet; the forty feet curve has remained nearly stationary on the whole." These curves indicate the form or contour of the outer slope of the bar. He also shows, from the same report, that the entire area, for a distance of a mile from the end of the jetties, lying in the track of the river discharge, has deepened on an average one foot, three and seven-tenths inches. The Commission of Engineers appointed to decide, among other questions, that of the admissibility of dredging refers for authority for so doing to the opinion of Gen. Humphreys, expressed in the Physics and Hydraulics of the Mississippi River, and they state that the amount of dredging done at the jetties is "utterly insignificant."

Mr. Eads quotes the following paragraph from Gen. Humphreys' letter: "Yet the facts exhibited by the reports of the officers inspecting the South Pass, show that the views expressed by many engineer officers, the chief of engineers among them, that a new bar would form at the sea end of the jetties, and that it would extend into the sea more rapidly than the old bar, are correct, even during the changes going on under the scouring power of the jetties, aided by dredging between and seaward of them." By extracts from the reports of the U. S. inspecting officer and the Commission of distinguished engineers, Mr. Eads clearly disproves the foregoing statement, and says: "I have shown conclusively, from the official reports on the jetties, that there has been no advance of the bar; that it has not been necessary to extend

them, and that there has been no shoaling in front of them and he further states, that instead of having to advance t jetties six hundred and seventy feet every year, as predict by Gen. Humphreys, they are two hundréd feet shorter th they were originally located.

In closing his forcible and convincing argument, he say "In absolute defiance of the plainest official evidence to t contrary, Gen. Humphreys makes the astonishing statemex that '*the results actually attained at the South Pass, disprove t views of Mr. Eads, and confirm those of the engineer depar ment;*' while the safety and ease with which the heavies draught ships already use the jetty channel, and the immens benefits resulting to commerce should convince even him c the wisdom of the government, in rejecting the advice of th chief of engineers, when deciding on the problem of impro ing the mouth of the Mississippi River." (See Appendix 1 for full text of this letter.)

CHAPTER XIV.

HEAD OF THE PASSES—WORKS DESCRIBED—FINAL RESULTS GIVEN, 1877 TO 1879.

In returning to the description of the works at the head of the passes, a brief resumé will be given of the works constructed previous to the spring of 1877, and their attendant results.

First.—The construction of the East Dyke and its results.

Second.—The construction of Dam No. I., Island Dam, and Lighthouse and Island Dykes, that marked the lines of the channel, and

Third.—The extension of these dykes, and then, in order to restore the volume diverted by these works, the construction of Southwest Pass Sill.

The remarkable improvement of the channel through the shoal attested the wisdom of the plan adopted.

As soon as the necessary funds were obtained from the government, a sill was also constructed across Pass à Loutre. Later in the work, as the results showed it to be necessary, the plan was still further extended by raising the sill across Southwest Pass; by the construction of Upper Dam, about two thousand feet above Dam No. I., by the extension of Island Dyke up stream to connect with this dam, and down stream to connect with the island, and by rebuilding the extension up stream of Lighthouse Dyke. An examination of Plate H will show the location of all these works.

The various works constructed from the spring of 1877 to

the completion of the work in July, 1879, will now be given in the order of their construction, and the final results will be described.

PASS À LOUTRE SILL.

The location of this sill and its alignment were determined by float observations, with a view of presenting a line at right angles to the current. The first mattresses were laid on March 31, 1877, and were connected with the old foundation mattresses at the up-stream end of East Dyke. The construction of this work was attended with greater difficulties than any other; for the mattresses were laid at flood river, the Carrollton gauge reading 7.5, when the work commenced, and reaching 11.0 before it was finished.

The process by which the mattresses were placed was similar to that employed on the Southwest Pass sill. For about one-third of the distance guide piling was used for the lower edge of the mattresses, with a waling strake stirruped to it, but it was ascertained later that the mattresses sank much more freely by using the side piles only. The size of the mattresses was at first 70′ by 40′ by 2′, but the river continuing to rise, it was found impossible to handle mattresses of these dimensions, and the width was reduced to twenty-five feet.

The water was from twenty-eight to thirty feet in depth; the current was at least three miles an hour, and its velocity uncertain, on account of the irregular fluctuations of the tide; the piles, on which the whole success of the work depended, were unfortunately weakened by age; large masses of drift-wood often collected above the guide piling or endangered the stability of the anchorages by striking against them; the mattresses were unwieldy masses containing about five thousand six hundred cubic feet, with a vertical surface of

hty square feet presented to the current; the unsupported ide piling, and even the anchorages that were stiffened in ery possible way, swayed back and forth in the strong rrent; all these causes made the greatest care and watchlness necessary. Every line and its fastening, the moveents of the tug and stone flat, and the handling of every rock eeded to be carefully watched, for when the mattresses ere in position and being loaded, both lines and anchorages ere very severely strained. On one occasion, on account f a defective link in an anchorage chain, a fleet of six matesses was lost, that had been placed in position and nearly nken. The chain broke; the two anchorages which held ie mattresses were broken down; the guide piles gave way; the lines snapped, and the mattresses went down the ass.

The last seven mattresses connecting the work with the st shore, were put in place May 8th. The location of the ll can be seen on Plate H. The estimate of the materi-s used and the detailed cost of the work appear in Apendix 15.

LIGHT-HOUSE DYKE.

In April, 1877, the dam and dyke, both having settled bew the surface of the water, were raised by loose willows id stone to nearly three feet above datum. The dyke was tended up stream three hundred and eighty feet above its nction with the sill, or to a point one thousand and twenty et above the dam. The depth of water where this work as built was about twenty feet.

The work was commenced by driving a row of guide piles bout twenty feet apart, curving gently to the eastward. even tiers of mattresses were laid along the west side of the iles, connecting with the old work. The first two courses ere thirty-three feet wide and the last twenty-one feet. One

course of mattresses, thirty-three feet wide, was laid on the eastern side of the piles, as a protecting apron. The upper part of the foundation of this work, not being of sufficient width, was undermined by the strong current that flowed around it into Southwest Pass. Several vessels ran into the dyke, carrying away the guide piling and disturbing the mattresses, and an excavation, with thirty-five feet of water in it, was made by the current on the west side of the dyke. In the winter of 1878 the work was rebuilt, in doing which a wide protecting apron was first placed on the Southwest Pass side of the dyke, extending from the sill to a point fifty feet above the upper end of the work. This apron conformed in its outlines to that of the deep excavation, its widest point extending one hundred and sixty feet from the guide piling of the dyke. The whole work was again raised above the surface of the water by loose willows and stone. A cross-section of the dyke is shown on Plate 13, facing page 136.

ISLAND DYKE.

The construction of this dyke to "New Cluster," in the fall of 1876, caused the remarkable deepening in the channel, which has already been spoken of, but it had its disadvantages and dangers. The head of water, caused by it, directed the current towards Lighthouse Dyke, endangering it, and a large eddy resulted below the head of the dyke, producing an extensive shoal, which extended almost to the center of the channel.

To remedy these evils the tilted mattresses of the dyke between Dam No. I. and "New Cluster," were torn down in April, 1877. This removal widened the water way, diminished the velocity of the current, and deposited the sand in the deep channel.

Before the removal of this part of the dyke, the averag

f the channel opposite it was thirty-five feet. In July hoaled to an average depth of twenty-eight feet. A so formed on the west side, extending diagonally into anel, reducing the depth over the area covered by it enty-three feet to nineteen feet. The depth in the above "New Cluster" also decreased, and until this is rebuilt, the shoaling was generally progressive, as seen by the following table:

ate.	Depth through shoal.	24-feet channel. Open. Width between curves	24-feet channel. Closed. Curves interrupted.
	Feet.	Feet.	Feet.
877.			
8.....	24.8	150	...
7.....	24.2	200	...
.....	25.0	300	...
.....	22.7	...	310
r 21.....	23.1	...	300
23.....	22.5	...	310
878.			
.....	22.5	...	400
16.....	21.7	...	1000
879.			
.....	27.2	450	...
880.			
.....	30.1	30-feet channel open. Width between curves 250 feet.	...

ork was done at the head of the passes from May, July, 1878, when preparations were made for com- the construction, the necessary funds having been d by the legislation of June of that year.

nconvenience and expense in towing mattresses from ip was so great that mattress ways were constructed ne mile above the head of the passes, on the batture,

on the west side of the river. The work on them was pended during the summer on account of the yellow epidemic, but was resumed in December of the same ye

The timbers of the ways were round pine piles about feet in length, placed six feet apart, at right angles with current. The slope of the timbers was one foot vertic six feet horizontal. The depth of water alongside the was nine feet. Their length, measured along the river, two hundred and thirty-five feet, so that three mattr seventy feet long could be built at the same time. Al and below the ways, and connecting with them were wharves for storing mattress lumber and other material, adjoining these a boarding-house was erected on piles.

SOUTHWEST PASS SILL.

On December 5th, 1878, preparatory work was comme for sinking two courses of mattresses on those laid in fall of 1876. A dyke of loose willows and stones was l extending from the shore line to a point about four hun feet from the river bank, where the depth was four Previous to laying the mattresses, examinations were on, above and below the sill, which showed that the sand mud had filled in among the willows and rock over the we half of the work; over the eastern portion of it the immediately above it was two or three feet greater th was before the sill was laid, but below it there had bee a slight increase in depth.

The plan of construction consisted in laying two cour mattresses, the first of which was sixty feet long, and thirty-three to thirty-eight feet wide. At the down-st end they were one foot thick; fifteen feet from the lowe two feet thick, and the same at the upper end. The line of the first course was forty-five feet above that o

old sill. The lower line of the next course was fifteen feet further up stream and the dimensions of the mattresses were similar to those of the course beneath it. The total height of the submerged dam or sill was nearly eight feet, the old sill acting as a protecting apron against the over-fall of the two upper courses. A sudden rise in the river during the construction of this work brought with it the same difficulties and dangers that had been experienced in the construction of the Pass à Loutre sill. Much of the difficulty was, however, overcome by the adoption of a very simple expedient for towing and handling the mattresses so as to keep the ends where the lines were fastened above the surface of the water. The plan consisted in placing two water-tight barrels under the upper edge of the mattress, while it was on the ways, so arranged that they could be released from their position before the mattress was sunken. It was possible by this simple means to sink mattresses of any ordinary size in a current of four miles an hour without difficulty.

The first mattress was placed on December 9th, and the work was finished January 31st, 1879. The first course of this new work extended to a point eighteen hundred and fifty feet from the shore line. The second course seventeen hundred and eighty feet, and the third course seven hundred and ninety feet.

ISLAND DYKE.

From the table on page 179, showing the changes that occurred in the channel after the destruction of the dyke between Dam No. I. and New Cluster, the necessity for rebuilding this work is apparent. This was done in March and April, 1879. The upper terminus of the dyke, however, was located about forty feet east of "New Cluster," in order that its direction might be nearer the axis of the current than was that of the former dyke. A broad foundation was first laid,

sixty-five feet in width at Dam No. L, and one hundr
at New Cluster. On this was erected a dam of tilte
trestles, with board sides, which rested against a
piles. Four hundred and fifty feet of this work abov
No. L was strengthened with several courses of mat
laid horizontally. The construction of this dam cau
immediate improvement in the channel.

The down-stream extension of this work, betwee
No. L and the island, sixteen hundred feet in lengt
raised to the surface by a substantial dyke of willo
stone. An extensive deposit had occurred, since 187
the whole line of this part of the work, and the fou
mattresses that were laid at that time were covere
mud several feet in depth, so that the average depth
water was only two and one-half feet.

UPPER DAM.

The construction of Dam No. L, in 1876, and c
works later, on the east side of the channel, had pro
very extensive growth up stream, of the shoal lying
Pass à Loutre and the inlet channel of South Pass.
further encourage this formation, and thereby induc
larger flow into South Pass, Mr. Eads decided to c
another dam, at right angles with the current, twel
dred feet above New Cluster, one half of it in the Sou
current, the other half in that of Pass à Loutre. T
called "Upper Dam," and was constructed between t
dle of April and the 30th of June, 1879. Its lengt
teen hundred and seventy-five feet, and the depth
previous to construction varied from twelve feet at th
to twenty feet at each end of the work, the averag
being sixteen feet.

A large part of the work was constructed by lay

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of foundation mattresses, and erecting tilted mat-
upon them, with tight board sides; but the ends of
e were built mostly of mattresses laid horizontally.
n of the construction is shown on Plate H, the
ction on Plate 13, facing page 136. Island Dyke
section of which is also shown on Plate 13) was
d to connect with the west end of Upper Dam.
uantities of willows and stone used on all the works
ead of the passes, will be found in Appendix 16.

FINAL RESULTS OF THE WORKS.

ie works at the head of the passes have now been
d. The comparative chart, Plate J, exhibits all the
of importance that have resulted from their con-
n.

dy of the three charts of the head of the passes,
, H, and J, which exhibit respectively the original
the final depths, and their increase and decrease,
w more difficult engineering than is often met with.
roblem, which, in the earlier description of the head
asses, was analyzed, its known quantities stated, and
own quantities pointed out, has been most success-
ved.

omparative chart, Plate J, shows how rapidly depos-
been made, wherever the current has been checked
works; the shaded portions on it showing deposit
75, and the unshaded portions showing deepening in
ie period. The figures on the chart show in feet
ths of a foot, the amount of deepening and deposit
ir respective areas.

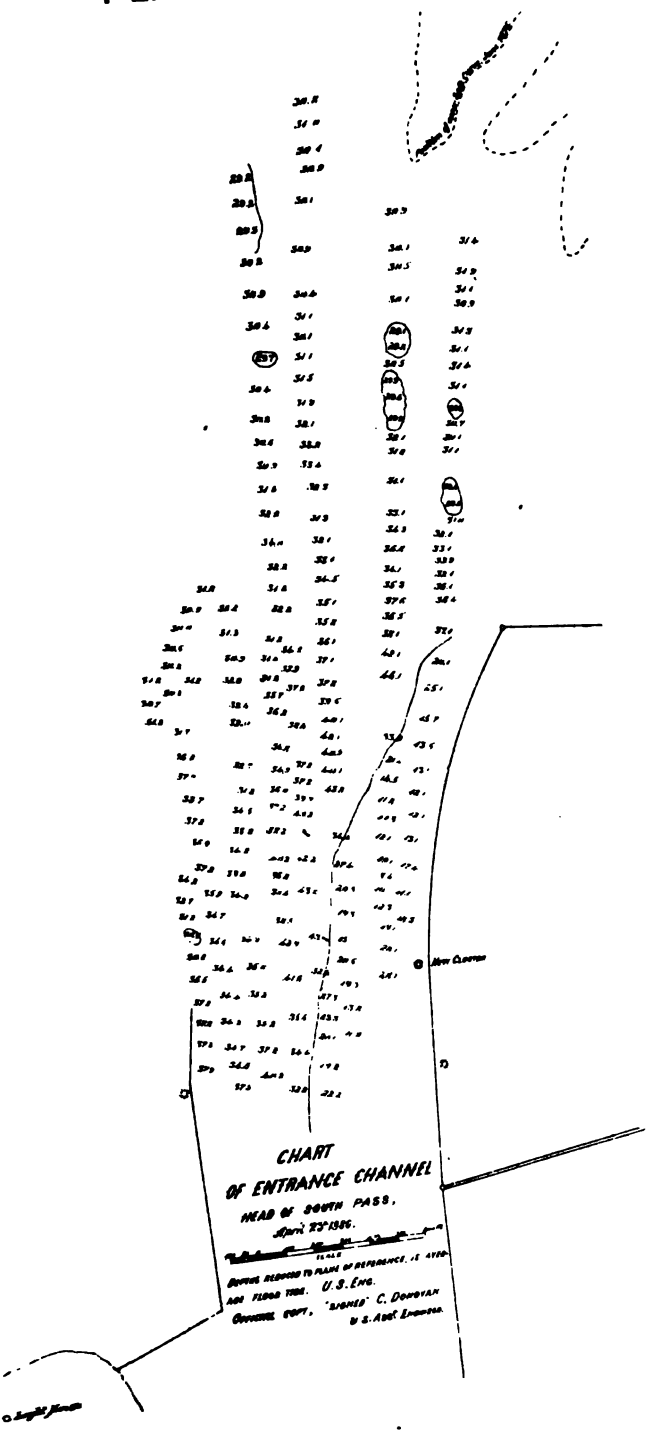
the jetties, so at the head of the passes, the works
aply assisted nature in opening channels and in build-
ks. Several of the works are already completely

buried in extensive deposits of sediment. Reeds, grasses, and willows now grow where deep water formerly flowed. Plate 15, showing the inlet channel as surveyed by Mr. C. Donovan, U. S. Assistant Engineer, April 23d, 1880, when compared with Plate H, will show a general improvement of the channel since July, 1879. The normal volume of the pass is nearly restored; for careful gauging of the three passes in January, 1880, showed that the percentage of flow into South Pass was nearly equal to that found by Marinden, in January, 1875. The power to accomplish all that is required to restore the full volume, and more if needed, lies in the works. The channel into South Pass is now the only one in which the natural forces of the river can effect a further enlargement. This enlargement is confidently anticipated, and it will be necessary within a short period, to lay a sill across the entrance of South Pass, to prevent too great development of the improved channel. When this is done, the entire volume of the great river will be under perfect and easy control. Light and inexpensive additions to the height of these submerged sills will produce any desired change in the volume discharged by either one of the three passes.

The materials were combined into convenient forms by methods entirely simple, yet novel, and the cheapness with which this was done, and the effectiveness of their application was so surprising, that this system of controlling silt-bearing currents has since been adopted by the army engineers throughout the valley of the Mississippi, and it may be advantageously copied by the older nations of Europe, where the same materials have been long used for similar purposes, but with much less economy and benefit.

When we contemplate the fact that these works are composed almost wholly of light willows, with a large portion of the mattresses standing on edge, simply as screens to check the current and cause deposit, they constitute a remarkable

PLATE 15.


CHART
OF ENTRANCE CHANNEL
HEAD OF SOUTH PASS,
April 23rd 1886.
SCALE
Soundings reduced to Plane of Reference, 15 Feet
Low Water Mark.
U. S. Eng.
Assistant Engineer.
Original Copy,
"Signed" C. Donovan
U. S. Asst Engineer.

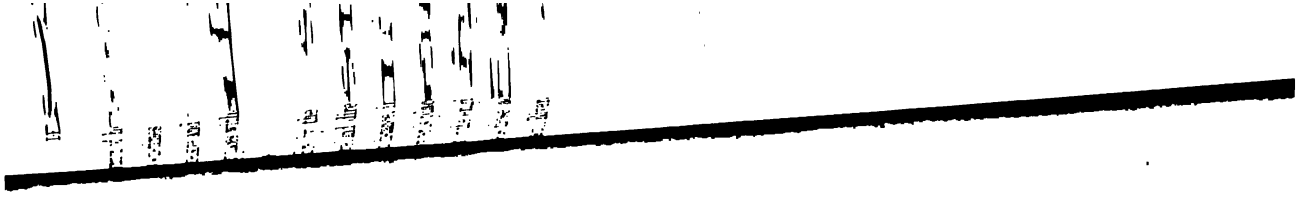


illustration of how completely the immense forces of nature may sometimes be controlled by a wise use of the most inexpensive and unsubstantial materials, which nature seemingly places within convenient reach of man for the very purpose.

Here, by the gentlest influences, the mighty current is swayed and directed completely obedient to his will. There is no instance, indeed, in the world where such a vast volume of water is placed under such absolute and permanent control by the engineer, through methods so economic and simple as those adopted at the head of the passes of the Mississippi River.

CHAPTER XV.

WORK DELAYED BY YELLOW FEVER—CONSOLIDATION OF SEA ENDS OF JETTIES BY CONCRETE AND CRIB WORK—REPORT OF COMMISSION AND PASSAGE OF AMENDATORY ACT.

It is with reluctance that we draw aside the veil from the face of the dark days of August, 1878, for they reveal a sad and mournful spectacle. Many of the men who, one year before, so nobly came up and agreed to stand by the work were summoned, not to further hardships and work, but to their reward.

No sooner had the finances of the work been placed on a sound basis for vigorous construction, by the passage of the act of June 19th, than the work was suddenly stopped by the yellow fever, which made its appearance in New Orleans about the middle of July. Every effort was made to prevent its entrance into Port Eads. Every avenue was guarded by rigid quarantine restrictions, which were enforced against pilots, tow-boats, and mail-boats. A case of fever was, however, inadvertently brought to us by one of our own boats, which we were compelled to send to New Orleans for materials and supplies. On August 6th, a few days after, three new cases appeared, and on the next day nine. The indications were that the dreaded disease would sweep through the crowded quarters occupied by the workmen. The conviction that delay would bring sickness and death to this crowd of human beings, far away from sufficient medical help, and that, in any event, the work must stop, led the

resident engineer, on the 6th and 7th of August, to discharge the whole force, except a few acclimated persons, and send them away at once, before the place became infected with the disease. Several of those, however, who left at that time were taken sick either in New Orleans or St. Louis, and some of them died. At Port Eads the disease spread, until sixty-four persons, about one-half of the whole population remaining, were taken sick, eleven of whom died.

Among the latter was Mr. O. D. Parmely, assistant of Captain Brown, who had been left by him in charge of the interests of the government. He was deeply lamented, for he was not only a most efficient and faithful engineer, but a noble and true man, esteemed by every one who knew him.

Among those who died at St. Louis was Captain William S. Nelson, who for many years had been connected with Mr. Eads in his various enterprises, but especially in the wrecking business, and as superintendent of the construction of fourteen iron-clad vessels, built by Mr. Eads during the civil war. He had superintended the construction of the *Bayley*, and had since then been in command of her. Only a word can be said here, when pages could easily be written, of the sterling qualities of this intelligent, faithful, and valuable man, who never shrank from, but always sought for the hardest and most exposed work. His mechanical skill, his long experience in hydraulic machinery and works, his entire forgetfulness of self, and his iron constitution, made him invaluable to the jetty enterprise, and in his death Mr. Eads lost not only one of his most faithful assistants, but one of his best and most cherished personal friends.

This roll of honor, if space permitted, would include nearly one hundred more, who had been faithful workmen in almost every department, who had been willing and prompt to do any and every hard work, and who had never been found wanting in the hour of need. Some of them covered

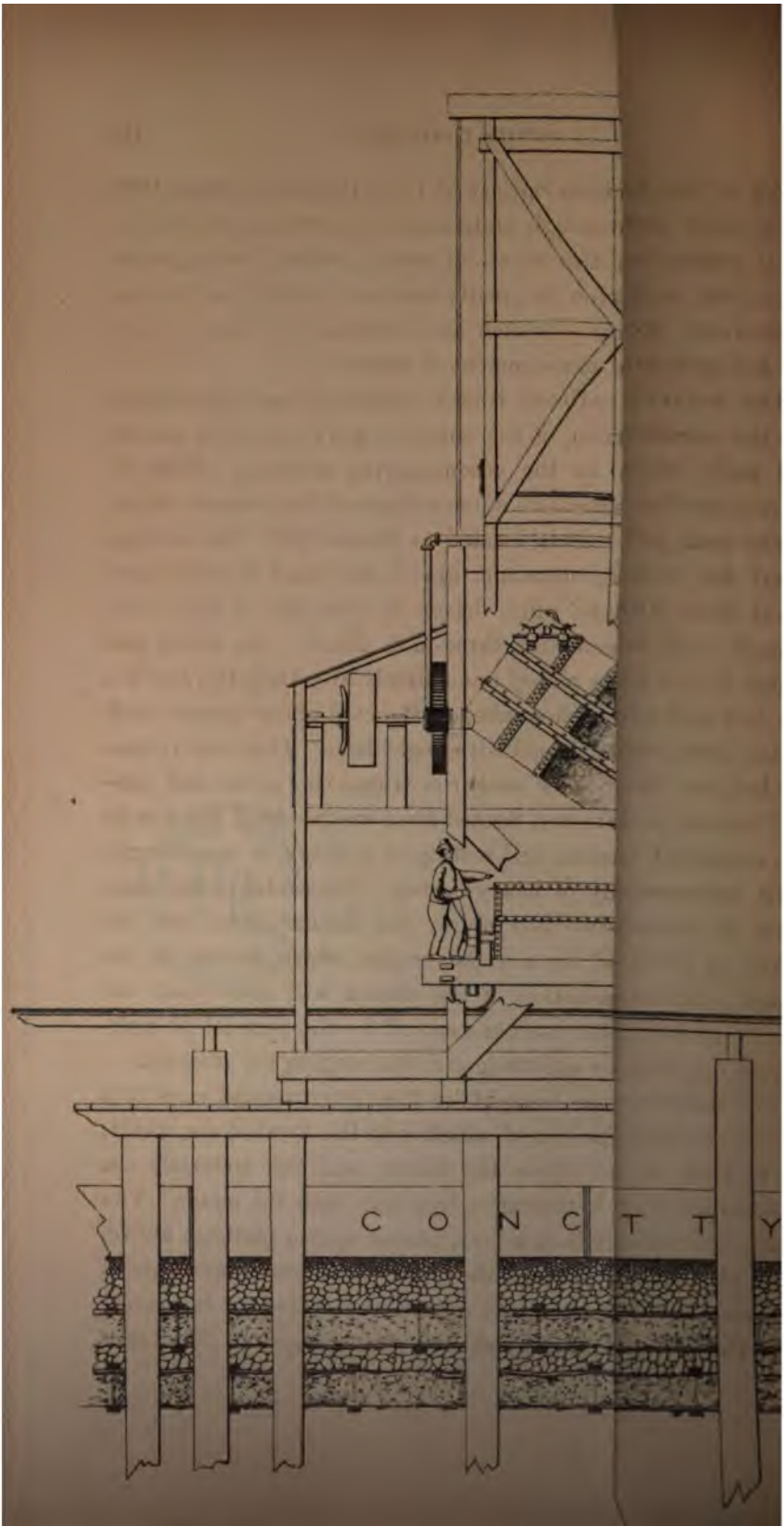
now by the sands lie in their resting-places near Kipp signal station, keeping watch, as it were, of the work they stood by until death cut them down.

Captain Geo. W. Adams was placed in charge of the work, and employed the laborers, as they recovered, in placing rubble stone on the jetties and wing dams.

During the fall Mr. Eads laid his plans for the completion of the work, and made all necessary arrangements for its vigorous prosecution, by constructing machinery for manufacturing concrete blocks, and in ordering supplies and all kinds of materials.

Much thought and examination were necessary to obtain the best means of consolidating the sea ends of the jetties, through and over which there was still much leakage. During easterly storms, large quantities of sand were washed over the low jetty from the reefs, seriously shoaling the channel by heavy material, which the current could only move very slowly. These causes delayed the enlargement of the channel on the crest of the bar. Experience had shown that rubble stone and even large dimension rock, could not withstand the lifting power of the storm waves, the sea very often picking up the smaller stone, and drifting them in piles like the sand. Large stones weighing about three thousand pounds had some time previously been placed on the surface of the jetty as an experiment. A few days afterward a severe gale occurred, and they were thrown by the waves entirely off the jetty. The only plan which it was thought would answer the requirements of the case was the construction, in place, of large blocks of concrete or *béton*, which in shape, position, and weight, would be able to withstand the most violent wave force to which they would ever be subjected. The following description of this concrete work is largely taken from a paper by Mr. Max. E. Schmidt, C. E., Chief Assistant Engineer of the jetties, written for the annual conven-

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C O N C T T Y

tion of the American Society of Civil Engineers, June, 1879. The exact and thorough statements, presented so forcibly in that paper, were the result of much patient investigation. The jetty enterprise is greatly indebted to him for his earnest work, for his dispatch and accuracy in surveys, and for his systematic arrangement of results.

The wharves, railroad tracks, machinery, and implements for the construction of the concrete work, are very clearly and fully shown in the accompanying sketches. Plate 16 represents the immediate surroundings of the concrete mixer, on the east jetty. It is located at Station 102. The storage wharf for cement, macadam, gravel, and sand is built upon about four hundred piles, driven at intervals of eight feet, capped, and floored with three-inch plank. The mixer (see Plates C and D,) is placed immediately over the jetty, and is a five feet and nine inches cube, constructed of one-quarter inch boiler iron, strengthened with angle iron. This box is suspended on two hollow cast-iron trunnions, seven and one-half inches in diameter, riveted from the inside of the box to two diagonal corners, and resting in a tower or frame-work, built substantially of heavy timber. The center of the trunnions is twenty-two feet above the datum plane, and the mixer is revolved by a steam-engine, which stands on the wharf. An examination of the sketch will show that one corner of the mixer has been cut off for the purpose of making an opening for admitting and discharging the material.

The materials are brought by wheelbarrows and carts to a steam elevator, the box of which is at the level of the wharf; it is then raised above the mixer, and the materials are discharged from it through a trap-door into the mixer. The water is let into it from a tank, placed upon a platform above, by a pipe passing through the hollow trunnions. After about a dozen revolutions of the mixer, the trap-door is opened and the concrete discharged into a dumping-car. The tanks

or receivers on the cars are six and one-half feet long, four feet wide, three feet three inches deep, and are nearly semi-cylindrical in form. They are built of one-quarter inch boiler iron, and the axles on which they turn are three inches in diameter, and are riveted by a round plate to each end of the receiver. By means of levers attached to these plates, two men can easily overturn the car and dump the concrete. The car is taken by a small locomotive to the place where the block is to be built. The jetty is prepared for the molds, or boxes, in which the concrete block is built, by first throwing the rubble-stone to one side, cutting away, if necessary, the old mattress work, filling the interstices with gravel or small broken stone, and leveling it off carefully to a fixed height, generally about six inches below datum. The box, a sketch of which is shown, see Plate E, is then placed upon the bed thus prepared, and the concrete, in sufficient amounts to fill it, is deposited in it from the car. These boxes are so constructed, that the sides can be easily removed after the concrete has become well set, and sufficiently hard to meet the force of the waves without disintegrating. The bottom of the box is made of inch boards, and the sides of two-inch plank. About two cubic yards constituted one charge for the mixer. The proportions for the ingredients varied somewhat, but not materially, according to the materials and location of the blocks. The usual proportions were :

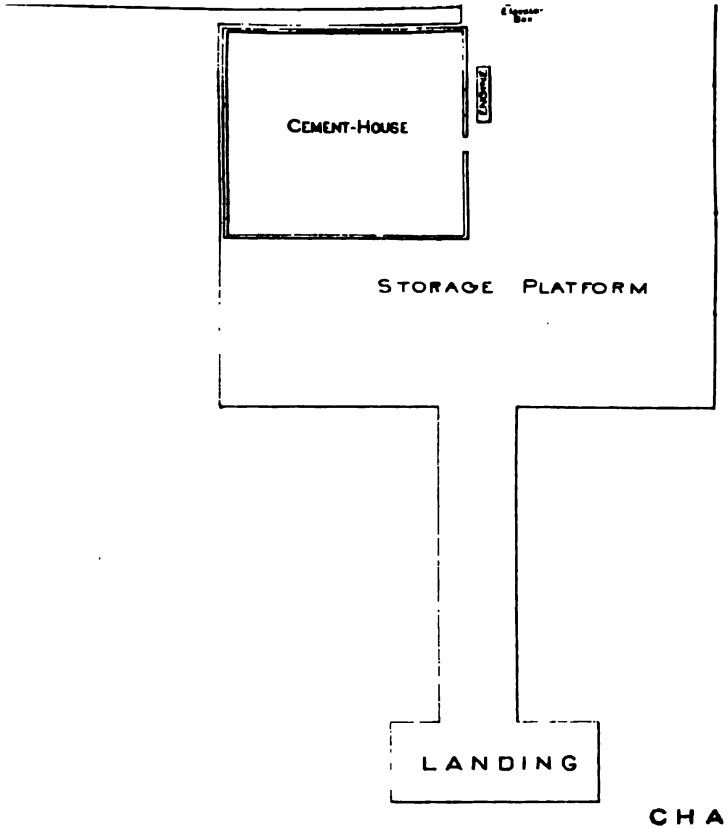
Three parts cement.

Three parts sand.

Three parts gravel.

Fifteen parts broken stone.

The amount of macadam was often reduced, and a small proportion of rubble stone was thrown into the concrete after it had been placed in the molds. At first the material was tamped, as soon as it was dumped into the molds, but this was found to be unnecessary, as the force of the fall from



RIVERSIDE

PLATE 16

PLAN
of immediate surroundings of the CONCRETE MIXER on EASTJETTY

10200 Fts below Eastpoint

SHOWING LOCATION OF WHARFS, WHAREHOUSE, ELEVATOR, MIXER, CONCRETE AND RAILROAD

SEE TEXT, PAGE

Scale of Feet




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the dumping-car was sufficient to thoroughly compact the concrete.

During the progress of the consolidation of the jetties, the Board of Army Engineers, which had been appointed in accordance with the act of Congress, of June 19th, 1878, arrived at Port Eads. The members of this board were Genl's J. G. Barnard, J. N. Macomb, Z. B. Tower, and H. G. Wright, and Col. William E. Merrill.

They addressed a letter to Mr. Eads, stating the subjects on which they were to report, and requesting him to furnish a statement of his plans for completing the jetties and auxiliary works, with his estimate of their probable cost, and also to present his views of what depth these works would ultimately produce, and to state what modifications of the act he desired, in regard to dimensions of channel and terms of payment.

In reply Mr. Eads submitted drawings of all works proposed for completion, with an estimate of their cost, which was three hundred and sixty-two thousand one hundred and ten dollars and sixty-seven cents. The following is an abstract of his letter. It is his belief that the natural discharge of South Pass will create and maintain a channel of a central depth of thirty feet, but no larger. In regard to the modifications of the terms of payment, he alludes especially to the fact, that they were arranged in the act to save the government from any loss, while the jetties were considered a doubtful experiment. As they are no longer an experiment, but a success, he should be paid for at least ninety per cent. of the work done. On this basis he calculates that the amount unpaid of the sum actually earned, is two million two hundred and eighty-seven thousand eight hundred and ninety dollars, with one million dollars still held in reserve by the government, as security for maintenance of the channel for twenty years, and that even on the basis of channel results,

already obtained, the government should pay him $1,773,000, and that this sum will not suffice to discharge all the indebtedness created in the construction of the work.

The Board report on six different subjects:

First.—Progress made in the construction of the works.

They give a description of them, with the estimate of the materials used in them.

Second.—Probable cost of completion.

They believe the estimate of Mr. Eads is sufficient for the completion of the works as designed by him, but state: "It (the Board) is unable to predict what will be the resulting depth on the bar, and as the only standard of completion is the attainment of a channel over the bar thirty feet deep and three hundred and fifty feet wide, it follows that an estimate of the probable cost for works necessary to produce such channel, if it ever can be produced, cannot now be made."

Third.—Results produced.

They give a table taken from Capt. Brown's report of December, 1878, showing at various dates the depths in the channel. A copy of this table, extended to include depths obtained in July, 1879, is shown in Appendix 17. In reference to the bar beyond the jetties, they say: "Outside of the jetties there is no present appearance of bar advance, and though during the past year soundings indicated variable conditions during different months, at the end of the year a scour of twenty-two inches is shown in the one and one-quarter square miles just seaward of the jetties, where during the preceding year there had been a resultant average fill of five inches."

Fourth.—Results that may probably be produced.

They doubt the ability of the jetties, even after consolidation and prevention of leakage, to obtain a depth of thirty feet, and a permanent channel twenty-five or twenty-six feet is all that can be expected. They refer to the probable ex-

tension of the jetties on account of bar advance, as a subject to which pre-eminent importance has been attributed. They refer to the report of Capt. Brown, in which the subject of scour and fill in front of the jetties is treated, and to the advance and recession of the contours, to show that up to July, 1878, there had been a deepening, and instead of an advance of the contours, an absolute retrogression and a disappearance of bar material in front of the jetties.

Fifth.—Probable permanency.

Wave action and destruction by the teredo are the principal destructive elements. As the effect of wave action thus far has been mostly superficial, and such action is by no means as violent as in similar exposures on the Atlantic coast, they think that the concrete work, flanked by enrockments of heavy stone on palmetto-log grillages, will resist the sea action. They do not believe that the teredo has penetrated or can penetrate far into the interior of the mattress courses, on account of deposits of sand and mud in them. They say: "In the ordinary sense of the word permanency, that is, capability of endurance of destructive forces, the works may be said to possess the attribute, to a reasonable degree."

Sixth.—Advisability of modifying terms of payment and dimensions of channel.

On this point they say: "The Board of 1874, instituted by act of Congress to determine the best method to secure an outlet from the Mississippi River to the gulf, either by a canal or by the improvement of one of its natural outlets, reported in favor of improvement of the South Pass at an estimated cost of $5,342,110, declaring that while its estimate was designed to cover every possible contingency of cost, it was believed the work could be done for a much less sum. No reason is known why Congress, which adopted this recommendation, should not have left the execution of the

work to its own agents, except that the present contractor, Mr. James B. Eads, offered to accomplish the results contemplated by the Board without payment unless those results were secured.

"It would seem, therefore, that this proposition of payments for results only influenced Congress to award the contract to Mr. Eads, instead of leaving the execution of the work to its usual agents."

This extract is very suggestive.

It plainly indicates that the Board considered Mr. Eads as simply executing works which were planned by the Board of 1874. He is deprived of any credit of originality in the matter, and is considered simply as an interloper, who had wrested from the usual agents of the government, by the attractive proposition to produce results before payment, the direction and execution of works which they had originally designed and recommended to Congress for adoption.

The results which followed the execution of the works are most favorably reported upon; but the moment the question arises as to whether Mr. Eads should be paid any portion of the one million and three-quarters, which he clearly shows the government would be safe in advancing, the spirit of the report is totally changed, and the sum of $250,000 is recommended to be advanced, not to relieve his necessities but to be strictly applied to the further execution of the work.

The unanimity with which the United States Congress, soon after receiving this report, voted $750,000 to Mr. Eads, to be paid at once, in addition to the $1,000,000 voted to him during the previous session, without any restrictions whatever as to its use, shows that it fully sustained the criticism which he published upon the recommendation of the Board, and in which he refers as follows to the claim of *originality* set up by this Board for the Board of 1874, all of whose

members, it is proper to state here, were, when appointed, in favor of the Fort St. Philip Canal:

"I urged this plan" (the jetty plan) "of improvement *as the only proper one*, upon the attention of a large number of the members of the Forty-third Congress, in May of 1873, during their visit to the mouth of the river, and in the winter following I made a formal proposition to Congress to deepen the mouth of Southwest Pass by the jetty system, and offered to *guarantee* its complete success, *before* any member of the Corps of Engineers (so far as I can learn) had ever expressed officially or publicly any *preference whatever* for this method of improving the mouth of the Mississippi over that of a canal, and long before the Commission of 1874 was ever thought of; indeed the very creation of the commission was the result of my proposal, and the opposition it evoked from some of the prominent engineers of the army." * * *

"The unusual severity of those provisions of the jetty act, by which an almost entire completion of the work was really required for a total payment of less than one-third of the agreed price, can only be attributed to the hostility evinced by some of the members of the Engineer Corps of the Army. Their arguments against the plan and their determination that this great work should not be intrusted to me, gave birth to all kinds of predictions of evil and failure. Their antagonism naturally enough alarmed Congress, and resulted, first, in the enactment of the severe provisions referred to; and second, in requiring me to accept the South instead of the Southwest Pass. The bill, as it passed the House, provided for the improvement of the Southwest Pass. In the closing hours of the session, however, the Senate Committee, as advised by the Commission, substituted the South Pass, but against my own protestation, and *without the advice of experts*, it insisted on my agreeing to produce at this little pass, depths and widths of channel similar to those I had pro-

posed for a pass four times as large, or else see the execution of my project put into the hands of its opposers." * * *

"I think the members of the Forty-third Congress will dissent from the inference sought to be created by the Board, namely, that the method of improvement adopted by that Congress was originated by the Commission of 1874, and that but for my proposal the engineers of the army would have been intrusted with the building of the jetties, for the facts show that the Commission of 1874 would not have been created but for my proposal, and that if I had not made it, and urged the jetty system with all the ability I could command, the 'usual agents of the government,' instead of being intrusted with this work, would, in all probability, now be digging in the sickly marshes of Louisiana, the canal recommended by a prior commission.

"Of that stupendous project, General Barnard, when advocating 'an open river mouth,' said, 'It would be a rash confidence that would anticipate a completed Fort St. Philip Canal earlier than 1884.'

"From these facts it is evident that if it had not been for my proposition to deepen the mouth of the Mississippi River by the jetty system, the commerce of the vast empire which constitutes its valley would to-day, and for years to come, be fretted and hampered by the bars at the mouth of the river, or be compelled to seek expensive and unnatural routes to the seaboard." * * *

"It remains to be seen whether an American Congress is prepared to put the stamp of condemnation upon individual enterprise, and decline to act with justice and liberality toward one who, in the face of unprecedented difficulties, has secured to the Valley of the Mississippi, and to the whole country, a deep and permanent outlet from the river to the sea."

It is proper to state as a matter of history, that General

Barnard, early in the controversy between Mr. Eads and certain engineers of the army, took sides in favor of the application of the jetty system to the mouth of South Pass, and doubtless contributed largely by the influence of his well-earned reputation as an accomplished engineer, in securing the adoption of that system. He was, however, at no time in favor of confiding the work to Mr. Eads; yet its success was of the utmost importance to his professional reputation, as upon it depended the evidence of the correctness of his views upon the subject, and throughout the entire enterprise he was deservedly recognized as one of its warmest friends; but there is no foundation whatever for the claim of originality set up in favor of the "usual agents" of the government, in the report of the Board of 1879, of which Gen. Barnard was President. It is true that a Board of which he was a member, in 1852, recommended a trial of the jetty system at Southwest Pass; but it was only as an alternative to be tried in case of the failure of a trial by the dredging and stirring process, which was recommended by that Board to be first tried. Certain it is that no officer of engineers, from that time forth until 1875, put himself on record in favor of the jetties; not even Gen. Barnard himself, who had given to the subject much more study no doubt than any other member of the Corps of United States Engineers; for while Mr. Eads had arrived at the conviction in the summer of 1873, that the jetty plan was the *only* correct method of improving the mouth of the Mississippi, and had given his opinion the most unqualified expression by proposing to guarantee its absolute success, in January, 1874, we find Gen. Barnard still hesitating to put himself squarely upon the record in favor of the jetty system, and in a letter addressed to the Chief of Engineers, April 29th, 1874, explaining the motives that actuated him in submitting a minority report, which had been severely criticised by Gen. Newton, the ranking member of the ma-

jority of the Board, he states: "I would in the first place remark, from first to last I felt myself charged with a gravely responsible duty; that I approached the questions presented to the Board perfectly unprejudiced; if in *any way* biased it was in favor, not against, the canal as a great engineering structure, outdoing in magnitude and interest the remarkable work I had recently visited in Holland, and, moreover, with the most conscientious desire not only to arrive at the true and best solution, but to do so in harmony and co-operation with the other members of the Board." See letter of May 22d, 1874, from Chief of Engineers to Secretary of War, transmitting letter of Gen. Barnard, dated April 29th, 1874.

On other subjects treated by the Board, Mr. Eads alludes

First.—To the question of bar advance, on which he says: "Prominent among the evils which were prophesied by the enemies of the jetties was that of the formation of a bar at their mouth. It was declared that if a deep channel *could* be obtained, it would have no permanent existence, but would soon be rendered valueless by an advance of the bar. So persistent has been the cry of BAR ADVANCE, in official and unofficial publications, and so widely has it been circulated through the medium of the press of the country, that these predictions have given rise to grave doubts upon the subject in the minds of many of those who were deeply interested in and who sympathized with this effort to give relief to the commerce of the Mississippi River. Facts were not wanting to dispel these doubts. The reports from time to time of the government officer in charge of the works (Capt. Brown), and the charts which he submitted from official surveys made by himself, conclusively demonstrated the utter falsity of all allegations in regard to a 'bar advance'; but in the face of these reports and accompanying charts, the enemies of the work have persisted in repeating their assertions to the contrary. The report of the Board of

Engineers, which we are now considering, certainly puts forever at rest this much vexed question, and dispels all doubts upon the subject."

Second.—The results within the jetties.

"The next important matter settled by the Board is that relating to results produced within the jettied channel. The opponents of the jetties, as we have seen, started with the prediction that no reliable results would be achieved, and sought to induce the belief that the improvement from time to time in the channel was not a general one, but that a deepening in one place involved a shoaling in another. The report of the present Board disposes very summarily of all such assertions. After quite an elaborate detail of the results produced, the Board says:

"'The maximum bar depth that has been obtained prevailed December 14th, 1877, when it was 23.7 feet. At the date of the latest survey, December 28th, 1878, it was twenty-three feet. This slightly decreased bar depth by no means indicates actual retrogression in the progress of results. On the contrary, *there has been constant progressive general improvement in the jettied channel, at no time more evident than at present.*'"

In reference to that portion of the report which refers to the channel dimensions, he states that, as the question was a vital one, it should have had careful attention given it by the Commission, also that they have greatly misunderstood him when they allude to his expressed ability to attain the depths and widths of channel prescribed in the act; for he strongly inferred in his letter that they could not be obtained without forcing more water through the pass and thus endangering it and the jetties. He says: "That two members of the Board at least had settled convictions upon this important question, and that the entire Commission of 1874 fully agreed with them, is evident from the testimony given by these two

members (Gens. Barnard and Wright) before a committee of the Senate in 1878. Gen. Barnard, in his testimony, said:

"'Question.—Suppose the scouring force between the jetties should deepen it from seven to twenty-three to twenty-four feet; now suppose the scouring force with the present water in it is exhausted at twenty-four feet, would it be safe to turn in any water from the Southwest Pass, and from Pass à Loutre from the main river, through this South Pass, to add to the scouring to make it thirty?' Answer.—'I have no confidence in it; nor was that ever recommended by the Board of 1874. I do not say it cannot be done, but to be safe, I would say it should be a slow process. It would require much labor and great expense. It would create an additional "head," and the results in the case of that kind are not easily foreseen. If done at all, I would advise it to be done very carefully and slowly, and in that way probably more water would be directed in the pass. It would have to increase its own section all the way down in order to carry that water.'

"Gen. Wright, in answer to the question as to the advisability of forcing more water into the South Pass, in his testimony said:

"'The Commission of 1874, which got up the original plan of the jetties, discussed that matter at great length, and it was, I think I may say, the unanimous opinion of the members that the size of the pass could not be interfered with: that what we wanted was that the regimen of the pass should not be disturbed; and to that end there is put into the estimates a certain amount—I don't remember whether specifically or not, though I think it was—to prevent any enlargement of the pass at all.'

"In face of this record further comment is unnecessary."

In reference to the recommendations of the Board he says:

"Having thus given the facts found and submitted by the

Board, we come to consider its recommendations. These are in brief as follows: 1. That $250,000 of the twenty-six foot payment be advanced to me, to be expended under conditions similar to those imposed by the third section of the act of June, 19, A. D., 1878; and 2. (in the language of the Board), 'As every additional foot in depth of channel is a benefit to commerce, we would suggest the advisability of a change in the terms of payment in the original act, so as to allow of payments for each additional foot gained, instead of for every two feet, the channels and payments to be as shown in the following table.' * * *

"In the face of the great results accomplished and about to be accomplished, and with less than one-third of the price of the works paid, the Board recommends no action whatever by Congress which would really afford me the relief which my necessities demand. The report is rich in expressions of approval of the work—poor only in its recommendations. Of what avail to me would be the advance of $250,000 hampered by the condition that it be expended only on the works? Would it serve to relieve me from the mountain of debt which I bear? Would it pay, even to a small extent, the contractors whom I have employed, and who have devoted their whole fortunes and years of labor to this great work? The liberality of this recommendation of the Board is only equaled by that of its second recommendation, which in plain English may be stated thus: 'The works will not, we believe, produce a greater depth of channel than twenty-six feet; we recommend that for every additional foot *over* twenty-six feet secured, Mr. Eads be paid the following sums of money.' * * *

"The Board, in its report, uses the following language:

"But it should be remarked that a channel of less depth than eighteen feet at South Pass was not necessary. * * *

"The useful result accomplished is, therefore, 'a channel

from eighteen feet to twenty-three feet.' In this connec tion the Board might have added that a permanent channe eighteen feet in depth was worth to the government $250,00 per annum, as it cost about that amount to maintain the un certain channel at Southwest Pass."

For full text of the report of the Board and Mr. Eads's re view of it see Appendices 18 and 19.

Soon after the presentation of the report of the Board an the review of it by Mr. Eads, the Senate Committee o Transportation Routes to the Seaboard reported favorabl on a bill of relief, and an act was passed by Congress and ap proved by the President of the United States on March 3d 1879, whose general provisions were a payment in cash at onc of $750,000, a payment of $500,000, when a channel twenty- five feet by two hundred feet is obtained, $500,000 when a channel twenty-six by two hundred feet is obtained, and $500,000 when thirty feet is obtained, without regard to width.

For the full text of the act, see Appendix 20.

The construction of the concrete blocks was pushed for ward as rapidly as possible on both jetties; the work bein confined to those portions seaward of Station 102.

Afterward the work was extended above the mixers t Station 90 on the west jetty, and to Station 65 on the eas jetty.

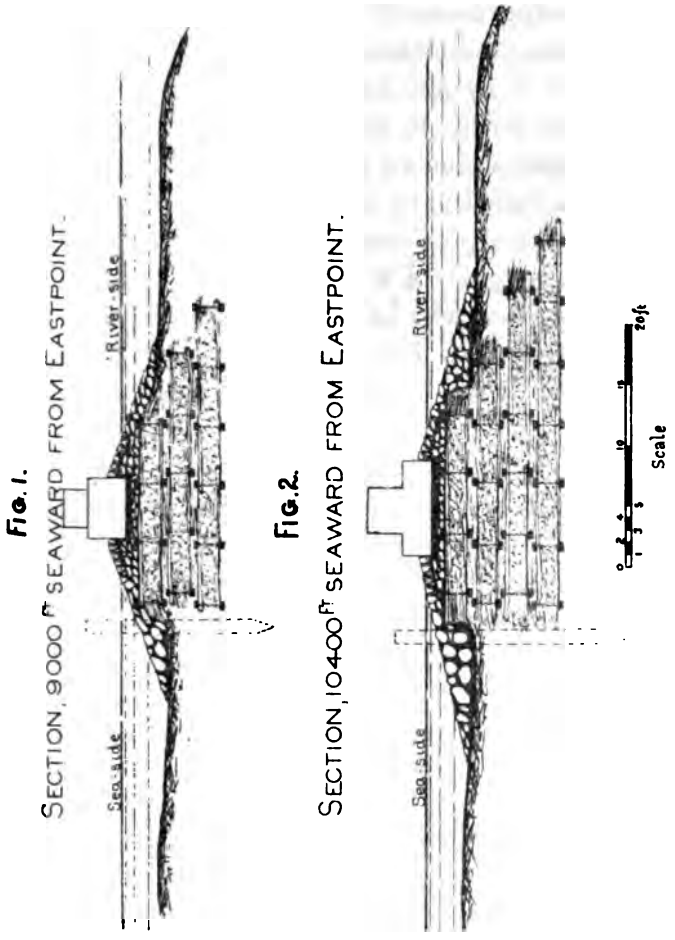
The size of the blocks varied from three and a half fee wide, three feet thick, and sixteen feet in length at Statio 65, to thirteen feet wide, five feet thick, and fifty-five feet i length at Station 117. The weight of the concrete when dr is about one hundred and fifty pounds per cubic foot, so tha the heaviest blocks, which were placed at the sea end of th east jetty weigh over two hundred and sixty tons.

The concrete work of the east jetty extends from Statio 65 to Station 118, or about one mile in length. On the we

PLATE 17

SECTIONS

of the lower parts of East Jetty.



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jetty it extends from Station 90 to the end of the jetty, about half a mile. The blocks on both jetties gradually increase in size toward the sea ends. A continuous parapet of concrete is built on the blocks of the east jetty rising to a height of five feet above datum at Station 65, and nine feet at Station 18. A portion of the parapet is built of rubble masonry. There are seven thousand three hundred and twenty-six cubic yards of concrete on both jetties, and four hundred and sixty-three cubic yards of rubble masonry.

In order to render the work stable and durable, the very best materials were obtained for its construction.

The macadam is a hard compact limestone, weighing about one hundred and fifty-five pounds to the cubic foot. It is broken so as to pass through a three inch ring. The gravel is a clean wash gravel from the bed of the Mississippi River, about one hundred and thirty miles above New Orleans, being deposits from a creek near by; the pebbles vary in size from one-thirtieth of an inch to one and one-half inches in diameter. The sand is moderately coarse and sharp grained, the diameter of the grains averaging one-fortieth of an inch. It is obtained from the shores of the Mississippi Sound, between New Orleans and Mobile. The sand found at the delta of the river is not suitable for concrete work, being composed of fine round particles about one one-thousandth of an inch in diameter, and generally mixed with clay.

The value of concrete depends so much upon the bond which exists between the ingredients, that the cement which performed this office should be described.

It was believed that the ordinary light weight cements would not be suitable for work exposed immediately to the action of salt water, and the violence of the waves.

The following specifications were therefore determined upon:

First.—That the cement must resist without fracture a ten-

sile strain of two hundred and fifty pounds per square inch seven days after the specimen briquettes of two and one-quarter inches sectional area were made, during six days of which they must be immersed in water.

Second.—That at least eighty per cent. of the cement must pass through a sieve of two thousand five hundred meshes to the square inch; and

Third.—That the weight of a struck bushel must be at least one hundred and ten pounds.

Careful inquiries and examinations were made to find a cement that would not only conform to these specifications, but would be recommended by those who had used it under similar circumstances.

The tests made by Mr. W. W. Maclay, of the Department of Docks of New York, showed that Saylor's American Portland cement was fully equal to these requirements, and ranked with imported Portland cements. As large quantities had been used by that department, and had given satisfaction, a contract for delivering seven thousand barrels was made with the general agents, Messrs. Johnson & Wilson, 93 Liberty street, New York.

As this cement has performed an important part in the construction of the concrete, a description of its manufacture will be given. The material and works are in Pennsylvania. It is manufactured by what is termed in Europe the dry process. The stone, as it comes from the quarry near by, is ground in steam crushers and mills to an impalpable powder. It is then thoroughly mixed in an iron mixer on its way to the pug mills, where it is tempered with water. The product is then treated in a manner similar to the English method of making Portland cement, namely: it is spread out upon drying floors, and when stiff is cut up into blocks the size of bricks; these when dry are placed in the kilns, with alternate layers of coke, and burned. The clinker is then care-

fully selected, the pulverulent scorified and the underburnt taken out; it is then ground and conveyed to the store-rooms, the area of which is nineteen thousand square feet, where it is left a few weeks to sweat. It remains in bulk in store until needed, and is then packed in barrels well lined with paper, to protect it from dampness—a provision especially needed in the damp climate found at the mouth of the Mississippi River. This cement, as shown by chemical analysis, is composed of the following ingredients: silica, 22.04; alumina, 10.11; sesquioxide of iron, 1.61; sulphate of lime, 1.78; lime, 61.93; magnesia, 2.13. Total, 99.60.

Eleven kilns are used for the manufacture of Portland cement, with a capacity of five thousand barrels per month. The ordinary natural cements differ from Portland cement in the following particulars. They are simply the quarried cement rock, ground once only, in which are wanting several of the ingredients enumerated above, viz.: Silica, Alumina, etc. (The tensile strength of cements, given following, is from tests made seven days after mixing, if not otherwise specified.) Natural light weight cements, gauged neat, give about seventy pounds per square inch tensile strength, and weigh about seventy-five pounds per struck bushel.

Careful tests applied to about one-tenth of the twelve thousand two hundred and seventy-five barrels of Saylor's Portland cement received at Port Eads, give the following results: Percentage of fineness, eighty-eight; average weight of struck bushel, one hundred and twenty-two pounds; average tensile strength (one part cement two parts sand), one hundred and two pounds per square inch; maximum one hundred and thirty-three and one-half pounds; average tensile strain, neat cement, two hundred and sixty-two and one-quarter pounds per square inch, and the average of the maximum breaking strains of each lot, of about ten briquettes, three hundred and twenty-five and one-quarter pounds per

square inch. Since, on account of the difficulty of manipulation, it was almost impossible to obtain perfect parallelism between the line of strain and the larger axis of the briquettes, this latter test may possibly reveal the actual strength of the cement more nearly than the average of the breaking strain of the whole number in each lot. All the briquettes were two and one-quarter inches in sectional area, and were moulded to fit the clamps of a Riehlè testing machine.

The cement, either in briquettes or in work, increases in strength and hardness with age. Tests made by Mr. Maclay show a tensile strength of five hundred and ninety-nine pounds per square inch with briquettes ten months old, and at the manufactory the cement, gauged neat, withstood a tensile strain of eight hundred and sixty-six pounds without fracture with briquettes nineteen and one-half months old. The quality of the cement was remarkably uniform. In the actual construction of the blocks, and in the severe tests given the concrete in sixteen months of exposure to the waves, the cement has proved itself to be first-class in every respect. It has so hardened and solidified the blocks that even the edges and corners exposed to the sea are as clean cut to-day, as when, two weeks after construction, the plank moulds were removed and the waves commenced to dash against them.

The construction of concrete generated new wave forces which the rubble stone or even the dimension rock could not withstand. The waves which previously swept over the jetties and expended their force, were by the concrete blocks converted into racers, which in storms swept along the jetties with terrific force, picking up the rock which lay upon the slopes, scattering it in every direction, and, where an obstruction opposed its further course, piling up the rock upon it and at times hurling them over the concrete blocks. To prevent this action of the waves, which, if continued any length

of time, would undermine the jetties, spur cribs were built and placed about one hundred feet apart, on both sides of the jetties, wherever they were exposed to the racers. These cribs were loaded with rubble stone. The crib work for protecting the ends of the jetties was constructed of palmetto logs.

The palmetto is a species of the palm. Its wood is very fibrous, tough and corky. The fibers are intricately interwoven with each other, and the wood resists the attacks of the teredo. It weighs about forty pounds to the cubic foot. The plan and manner of constructing these cribs are seen in figures 4 and 5, Plate E. Before building them, careful examinations were made to ascertain the depth of the water and the irregularities of the bottom. A plan was made accordingly from which the crib was constructed.

"Referring for an example to the one on the drawing, there are fifty-one palmetto logs (A—A, see Figs. 4 and 5), each twenty-two feet long, which are placed in one row one foot from center to center, on the inclined ways formerly used for mattress building. This being the floor of the crib, a second row, consisting of five logs (B), is placed to break joints with the flooring, at distances of five feet from center to center. In the same manner the third row is placed, consisting of eleven logs, sixteen and one-half feet long, at distances of five feet between the centers, and breaking joints with the lower row. Augur holes are then bored, and the rows bolted to each other by three-quarter inch bolts. The fourth and fifth row of logs is then laid, as shown on the illustration, and drift-bolted to the lower layers. The crib is braced by short logs (C, C,) standing upright against the corners of the cells. Their lower ends are flattened and tightly wedged between the flooring, where they are fastened by bolts. In addition to these, stirrup bolts are used at every alternate corner of a compartment, which tie all the logs from the bottom to the top. The compartments are four feet square in the clear, and large enough to admit the largest boulders tha are

brought to the jetties. The cribs are pulled off the ways into the river by a tug, which takes them to the place for which they are built. Here a row of guide piles has been driven, about ten feet from the jetty embankment, to which the vertical edge of the crib is lashed. The sinking then takes place. The compartments are finally closed by large boulders, which are lifted into position by a derrick. The remaining space, of about ten feet in width, between the vertical edge of the crib and the jetty embankment, is filled with stone until it appears above water."

The above description and the plates of concrete and crib work are from a paper of Mr. Schmidt, entitled "The South Pass Jetties," read before the annual convention of the American Society of Civil Engineers, held at Cleveland, Ohio, June 17, 1879.

The sea end of the west jetty is entirely inclosed by this crib work for a distance of about three hundred feet above the end. As the end of the east jetty is still more exposed to the waves, a more extensive plan has been carried out. It is necessary for the stability of the work that it should be built with very flat slopes, so that the waves will meet no vertical obstructions to pound against. A cross section of the pier-head at the end of the east jetty is shown on Plate 18.

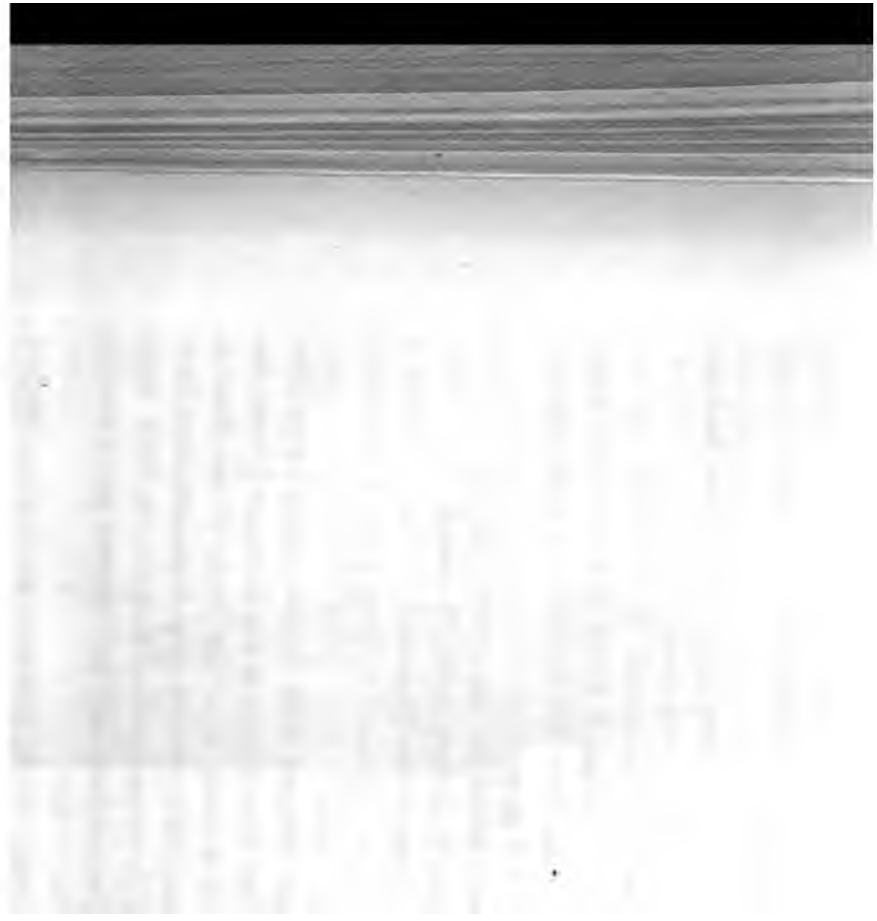
This shows the combination of the different kinds of materials and work. A longitudinal section of the pier-head would show the same plan of construction; a broad base, a flat slope, and the very best arrangement of the most suitable and durable materials in order that the permanency of the work may be assured. Landward from the concrete work on both jetties the final capping consists of rubble stone, rounded into a crown, under which, in a trench about six feet wide, gravel was worked into the mattresses, to prevent leakage. The height of this section of the jetties is about eighteen inches above datum.

The three principal materials used in the construction of

PLATE 18.

CROSS SECTION OF EAST JETTY THROUGH PIER HEAD





the jetties and auxiliary works were willows, lumber, and stone, the distribution of which is given in a detailed estimate in Appendix 16.

The total amount of each was: willows, six hundred and sixteen thousand one hundred and twenty-six and thirty-nine one hundredths cubic yards; lumber, thirteen million feet, board measure; stone, including concrete, ninety-nine thousand eight hundred and twenty-five and ninety-five one hundredths cubic yards.

The places where the willows were obtained have been described in Chapter VII. The lumber, with the exception of about one million feet obtained at New Orleans, was furnished by Messrs. Poitevent & Favre, of Pearlington, Miss., who from their promptness and reliability in supplying materials are entitled to great credit.

Nearly all the lumber for the jetties was delivered by schooners, carrying from forty to fifty thousand feet. By the course run, the distance from Pearlington (where the mills of Poitevent & Favre are situated) to Port Eads is about one hundred and fifty miles.

The stone was obtained from various places; from New Orleans and Port Eads, where it was discharged from sea-going vessels as ballast; from the banks of the river at Vicksburg, Miss., but by far the largest quantity from Rose Clare, Indiana, fourteen hundred miles above Port Eads, where it was quarried from the hard blue and gray limestone bluffs of the Ohio River.

The firms of Dippold and McDonald, and J. Sharp McDonald & Co., of Pittsburg, Pa., quarried the rock, and delivered it at Port Eads in coal barges, carrying about three hundred and seventy cubic yards, in fleets of from twelve to nineteen barges. The weight of the largest load delivered was about seven thousand net tons.

The total amount delivered by these parties was sixty-two thousand four hundred and forty cubic yards.

CHAPTER XVI.

FINAL RESULTS.

By comparing the description given in chapter seven, the mouth of South Pass, as it appeared in June, 1875, w the bird's-eye view of the jetties and Port Eads, given wi the present chapter, we can appreciate the external chan that have been made since the work began. Wharves, bui ings, jetties, and sea-going vessels have taken the place the desolation characteristic of the mouth of the Mississi River at one of its unused passes. But there are oth changes not shown on the sketch.

In the winter of 1878, ballast arriving in vessels was oft discharged on the banks at Port Eads. During the winter 1879 two steam derricks were built for this purpose, each which in ten hours removes from one hundred and fifty to tw hundred tons from the hold of a vessel, and places it upo the bank. The material thus discharged is brought fro all parts of the world; dirt from the bluffs at Cape Tow Africa; gravel from the Thames; granite from Rio de J niero; sand from France and Spain, and a great variety material from many other ports. About twenty-eight tho sand five hundred tons of ballast have already been plac upon the banks at Port Eads.

A good foundation, half a mile in length, and from sixty one hundred feet in width, has been prepared for stor materials for future construction. The deep water cl against the bank, the fact that its surface level is affec

PLATE 19.



BIRDSEYE VIEW OF PORT EADS AND JETTIES.

1. South Pass. 2. Grand Bayou. 3. S.W. Pass.

SOUNDINGS DEPTHS IN FEET.




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ightly by the tides and river floods (one foot on the at Carrollton raising the surface five-sixths of an inch rt Eads); the deep channel, seven hundred feet wide an indefinite length, where a large fleet can ride at with perfect safety, and the saving in towage; these ve great advantages to Port Eads, as a shipping port e cereals of the upper Mississippi, and the cotton and of the lower valley. This is one of the incidental bene- at commerce will reap by opening the mouth of the river. progressive and final channel results are seen more y by the study of the plates, than by any verbal state- The successive changes in the area of the cross-sec- and in the shape of the channel, and the increasing in the line of the deepest water, are shown on Plates l 21. (facing page 212).

first exhibits the development of the channel by five sections, and the second by a profile of depths in the the deepest water. An examination and comparison tes A and F will show, in a more general way, all the es that have occurred in the channel. The first is the of the U. S. Coast Survey, of May, 1875. The second survey of July, 1879, by Captain Brown; it shows a of nearly thirty-one feet through the entire length of ty channel.

ing the construction of the concrete blocks, the chan- veloped rapidly near the sea end of the jetties, the se in depth on the bar keeping pace with the extension blocks seaward. Between January 20th and April 8th, he east jetty concrete was extended from Station 105 tion 115, and the west jetty concrete from Station 102 . During the same period the depth on the bar in- l from 23.9 feet to 27.2 feet. The spring floods pro- a development the entire length of the jetties, which d on April 7th, in a channel twenty-five feet deep, and

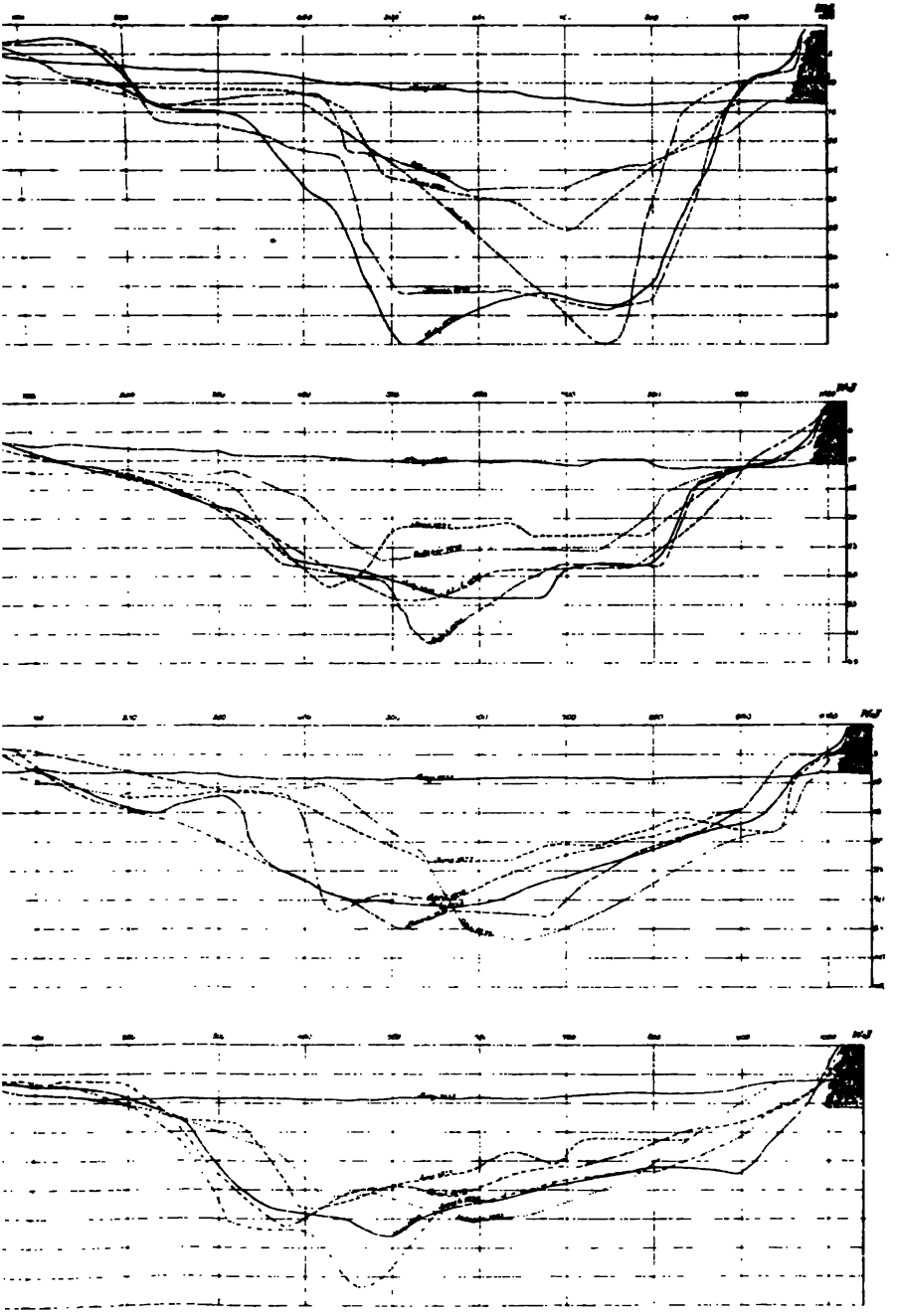
two hundred feet wide, which was certified to by Captain Brown. On June 18th, a channel twenty-six feet deep and two hundred feet wide was obtained, and on July 10th a certificate was given by Captain Brown, as follows: "I certify that on the 8th day of July, 1879, there was a channel at the mouth of South Pass, through the jetties, thirty feet in depth, without regard to width, measured at average flood tide, and extending from a wider and deeper channel in South Pass, to deeper water in the Gulf of Mexico." This was the maximum channel demanded by the law.

For examination by those who desire to follow more closely the successive changes in the channel, three tables are given in Appendices 6, 7 and 17. The first shows the depths in the line of the deepest water on twenty-seven sections, between East Point and Station 128, beyond the ends of the jetties, and at twenty-eight different dates between May, 1875, and January, 1880. The second gives the total distance, in feet, that the various contours were interrupted by shoaler water. These contours, eight in number, extending from twelve to thirty feet, are drawn from surveys made at twenty-five different dates. The third, taken from the report of Captain Brown, of July 1st, 1879, shows the depths that could be carried through each distance of two thousand feet, between East Point and the ends of the jetties. The table is made up from fifty-four surveys. A study of these three tables will show fluctuations in depths and distances, increase and decrease, advance and retrogression, but yet a general progressive development. The fluctuations were due,

First.—To the variable conditions of the river; its changing volume and its sediment differing in amount and character; and

Second.—To the construction work which was hurried forward or delayed by the various causes previously mentioned.

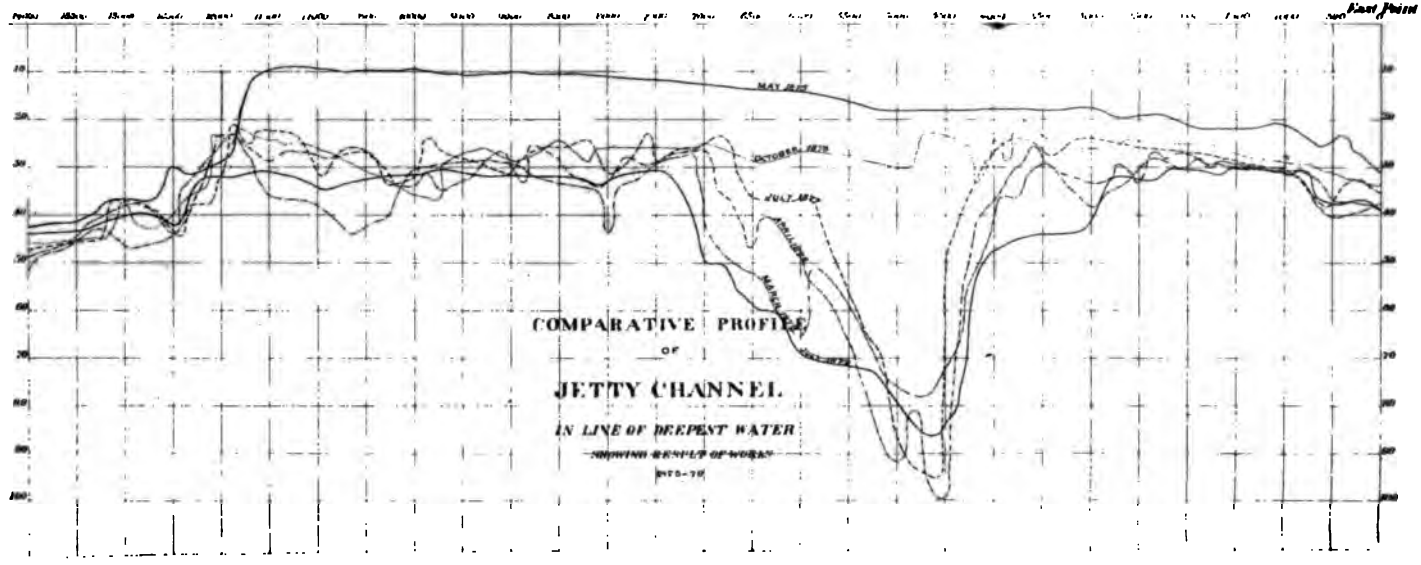
PLATE 20.



CROSS SECTIONS
OF
JETTY CHANNEL
SHOWING RESULT OF WORKS
1878–79

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PLATE 21.


COMPARATIVE PROFILES
OF
JETTY CHANNEL
IN LINE OF DEEPEST WATER
SHOWING RESULT OF WORK
1875-76
MAY 1875
OCTOBER 1875
JULY 1876
JANUARY 1876
MARCH 1876
OCTOBER 1876

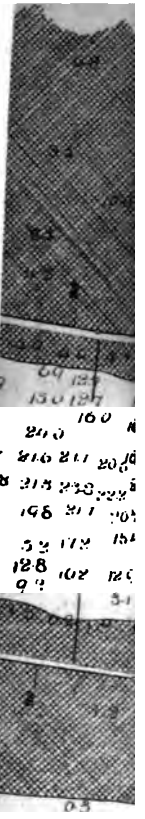



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The relation existing between the progress of the construction work and the channel development is shown on Plate 22, where the materials used in the work during each year, and the concurrent results which they accomplished in the removal of the materials composing the bar, and in increasing the depths of the channel, are exhibited graphically by four squares, each divided into four years, that the eye may catch at a glance the progress of the construction and its results.

It will be seen by an examination of this plate, that the amount of material removed from the bar in four years was three million two hundred and eighty-three thousand one hundred and twenty-three cubic yards. This represents the excess of scour over deposit in the formation of the channel, in the whole space between the jetties, in the entire distance from East Point to a point one thousand feet beyond the sea end of the jetties. The central portion increased in depth as the channel developed, and over the spaces on each side extensive deposits took place. Discarding this item of deposit, the current moved in all seven million six hundred and seven thousand one hundred and fifty-one cubic yards of material from the bottom, and carried it seaward.

Plate G still further illustrates this subject, and shows the extent of the scouring and depositing influences. The unshaded areas on the plate show where there has been deepening since May, 1875; the shaded areas show where deposit has taken place since the same date. The figures on the chart show the increase or decrease in the depths.

An examination of Plates A and F, in connection with the comparative chart just alluded to, will show to what extent land has been formed on the sea side of the jetties. For nearly a mile beyond the old land's end at East Point, the new growth is above the level of average flood tide, and grasses and reeds cover it.

On the west side of the west jetty the same process is go-

ing on, and clumps of grass here and there indicate that in a short time the whole area included between the west shore and the jetty, as far seaward as Station 90, will be above the tides and covered by vegetation.

We have endeavored by these various charts, sketches, and tables to show the results accomplished in the channel and on either side of it. Some of the channel results have been obtained by dredging, but the amount of material moved by this means has been so small, being only about one per cent. of the whole, that we have not included it in the exhibition of results. This artificial appliance has simply hastened a result which the current had ample power to accomplish, as is evident from the fact that it is now able not only to maintain the channel secured, but to still further enlarge it.

The unsuccessful attempts made at various times during the construction of the jetties and auxiliary works to permanently increase the size of the channel, when the conditions did not exist for maintaining it, show how utterly futile it is to attempt anything beyond slight changes in its shape; and they also prove the truth of the theory advanced by Mr. Eads, before the jetties were commenced, that it is impossible to permanently deepen the channels of sediment-bearing rivers without proportionately contracting them.

The engineer can control only the *form* of the channel.

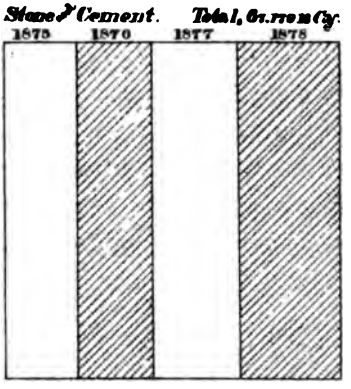
Dragging chains, harrows, and ploughs over the bar at times, when channel enlargement was particularly needed, resulted in some instances in a temporary increase in depth, but with no permanent increase of channel dimensions until the current itself had become sufficiently strong to make and maintain an enlarged channel.

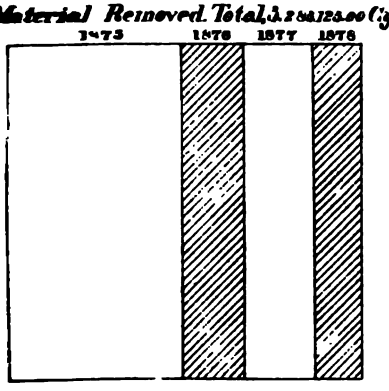
The material of which the bars at the mouth and head of the pass is composed, is so easily moved by the current that the slightest increase in velocity results in a deepening of

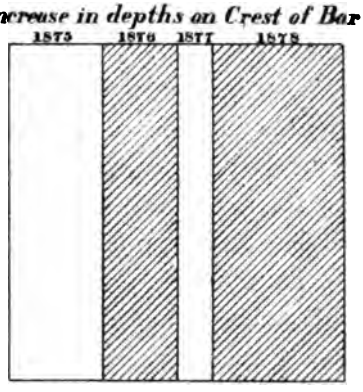
PLATE 22.

GRAPHICAL EXHIBITION
OF
WORK DONE & RESULTS OBTAINED









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nel, so that it may be stated as practically true that, r size of channel the current will *maintain*, it will *ob*nly a reasonable time be given it to accomplish the result; except in cases of tough clay, where its re- ay be hastened by artificial means. These principles n well proven by the effects of the works at the head ass, and the following illustration is given to show racticability of maintaining any artificial enlarge- the channel without contracting it. In the spring of er the entrance channel had shoaled on account of ruction of Island Dyke, alluded to in Chapter XIV. hn Grant, of New Orleans, who had had long experi- dredging, conceived the idea of deepening the chan- artificially increasing the velocity of the current at om. He constructed a machine for this purpose. atboat about eighty feet long, he erected a strong rk and arranged long posts, eight or ten in number, wered or raised vertically by being geared to a shaft by an engine. Attached to the foot of these posts ard apron, about three and one-half feet wide, ex- the whole length of the boat, and inclined outward at of about thirty-five degrees with the posts.

oat, with the posts and apron raised to the surface of er, was towed above the place to be deepened, and ng across the current by the tug which was towing side; the apron was lowered to the depth which it ired to produce over the shoal, and the boat, with still alongside to hold it broadside to the current, lown stream until the posts, which projected about below the apron, caught on the shoal and stopped . The current, obstructed by the apron and forced with increased velocity, quickly excavated the ma- us allowing the boat to drift slowly down stream shoal, deepening it as it went. The water was

usually about two feet deeper immediately above than at the down-stream side of the boat.

When the boat had thus drifted over the shoal s the material either into Southwest Pass, or int channel of South Pass between the dykes, it was to the starting point and allowed to drift agai shoal. When a deepening of about six inches effected over the whole area required, the apron w still deeper, thus planing or shaving off the shoal sive cuts. Owing to delays, caused by accidents t and by bad weather, the dredge did not work co Although a deepening of about two feet and the about five thousand cubic yards of material from t was effected, the causes that produced the shoal r lesser but normal depth, and thus the channel been deepened by this artificial appliance, shoale rapidly that the project was abandoned.

The results in the gulf beyond the jetties demar ful attention on account of the necessity for th nance. The controversial arguments before Cong the public press alluded to in preceding chapters the subject greater prominence than it deserves. and prejudices of the opponents of the jetties, du ception of the enterprise, had such an influence that the facts given by official reports during the the work were scarcely credited by many.

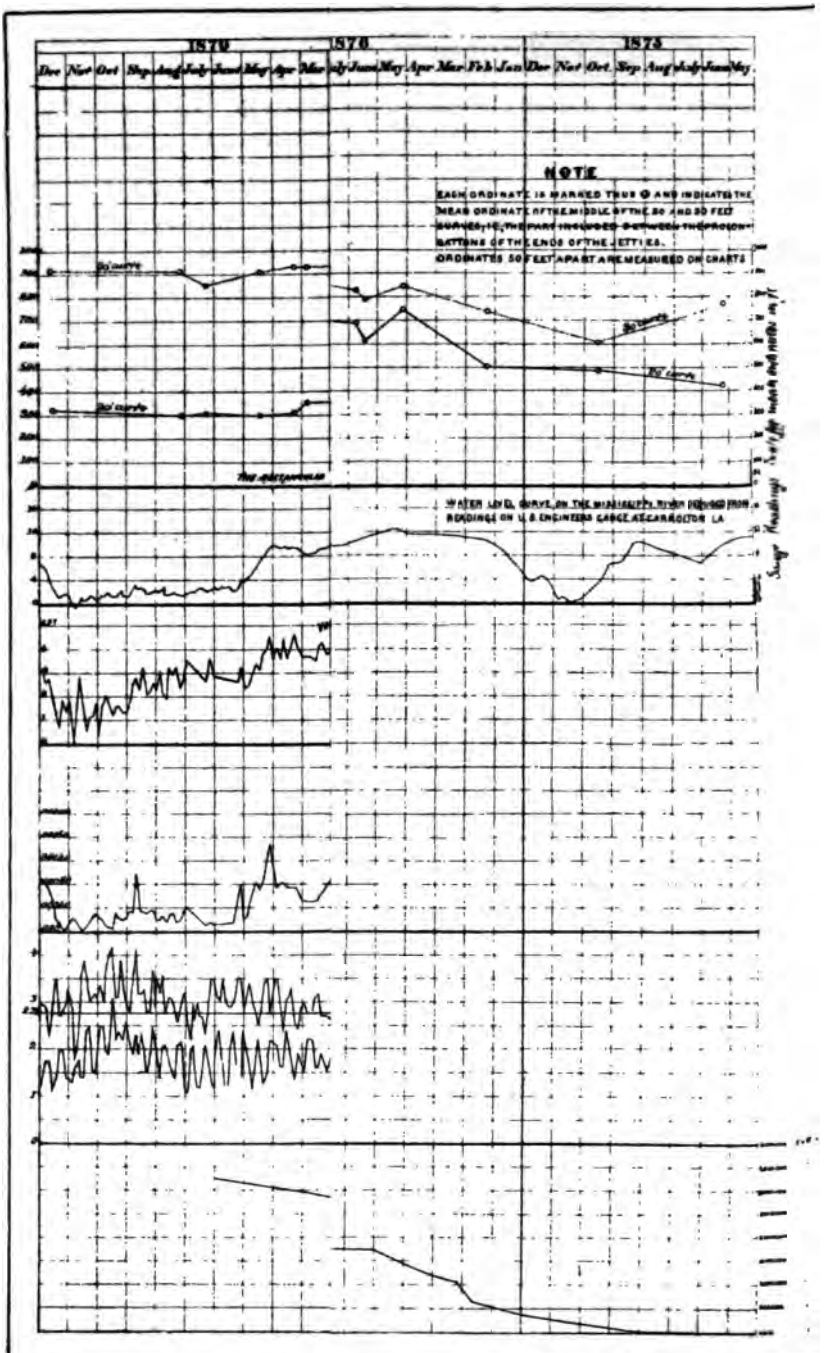
There are two methods of illustrating the result

First.—By means of curves that show at variou position of the outer face of the bar in refere points, and

Second.—By calculations to ascertain the scour over the area in front of the jetties, in the track discharge.

The changes in curves of twenty and thirty fe

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1879
1878
1877
Dec Nov Oct Sep Aug July June May Apr Mar
July June May Apr Mar Feb Jan
Dec Nov Oct Sep Aug July June May
NOTE
EACH ORDINATE IS MARKED THUS ⊙ AND INDICATES THE MEAN ORDINATE OF THE MIDDLE OF THE 20 AND 30 FEET SOUNDINGS, IE, THE PART INCLUDED BETWEEN THE EROSION PATTERNS OF THE ENDS OF THE JETTIES.
ORDINATES 50 FEET APART ARE MEASURED ON CHARTS
WATER LEVEL CURVE ON THE MISSISSIPPI RIVER REDUCED FROM READINGS ON U.S. ENGINEERS GAUGE AT CARROLTON LA

sea end of the jetties are shown on Plate K. In order to derstand the movements of these curves, their alternate ad- ice and recession, an explanation of the plate is necessary, on it the conditions and causes that affect them, and on ich they depend, are illustrated. These few irregular, and the casual observer unmeaning lines, are the results of ch caretul investigation, and they present graphically many portant facts. The vertical lines on the plate divide the ole time into monthly periods. The readings of the sur- e of the river on the Carrollton gauge, from May, 1875, to cember, 1879, are plotted from the daily records.

The horizontal lines represent every four feet on the gauge, the points of the curve are plotted carefully by the scale, as to represent the exact reading given by the record. curve of mean velocities, extending from February, 1878, December, 1879, is obtained by ascertaining the mean th velocity at the time of making the sediment observa- s. The curve showing ratio of sediment to water is tted from results obtained by taking specimens of water n the pass at Port Eads, at various depths, the sediment ag separated from the water and its relative weight ascer- ed. The points on the curve are the means of a great nber of observations. The dotted curve immediately un- it, showing the ratio of sand to water by weight, is the ult of observations by Capt. Brown, with a microscope of hundred diameters, by which the sand, or silicious par- les, is separated from the clay and its ratio to the whole ss estimated.

The high and low waters indicated by the readings on the ited States Engineer's gauge at Port Eads are also plotted, d the line of average flood tide is drawn through the curve high waters. The material removed in the channel devel- nent, which has already been illustrated in the graphical ares, is also plotted on this chart. The points on the

curve are ascertained and plotted from surveys made at characteristic conditions of the river—at low, high, and medium stages. The results are obtained by calculation. Comparative charts are made at each date, on which are drawn the areas showing scour and deposit since the previous surveys; the whole chart is divided into squares of one hundred feet, and the amount of scour or deposit at each corner of each square is ascertained by placing the charts of the two surveys one over the other and ascertaining the difference in depths. The total amount of material scoured or deposited is then ascertained, either by calculating the prism between parallel sections one hundred feet apart, or by measuring the areas of scour and deposit and multiplying them into the mean depths.

The two curves which remain to be explained are the twenty and thirty feet curves, which show the position of the outer face of the bar. They are obtained by means of twenty-one parallel ordinates, fifty feet apart, and drawn at right angles to an assumed fixed line, which at about Station 115 extends from the east to the west jetty. A skeleton plan, on which these ordinates are drawn in heavy black lines, is placed under the chart (which is plotted on tracing linen) and the distances are then measured on these ordinates from the fixed line to the point where the curves intercept them. The average of these twenty-one distances establishes the mean position of each curve, and gives us the points which are plotted and through which the curves are drawn. An examination of the plate will show how closely all the curves depend upon that of the Carrollton gauge, which indicates the rise and fall of the river one hundred and fifteen miles above Port Eads. All the curves rise and fall with it. Thus the current, its velocity increased by the rise of the river at Carrollton, accelerates the current at Port Eads; produces a scour in the channel, where the waters are confined by the

jetties; brings with itself a larger amount of sediment, which added to the material scoured from the jetty channel, produces a deposit at the end of the jetties and pushes out temporarily the twenty and thirty feet curves. Then as the curve of the Carrollton gauge descends, all the other curves on the plate descend with it—for the velocity of the current is diminished, its ability to transport sediment reduced, its abrading force weakened, and the bar, no longer pushed out by sedimentary deposits, recedes by the action of the waves and littoral currents.

The results exhibited on this chart, gathered from continued and careful investigation, conclusively prove the theory advanced by Mr. Eads during the earlier discussions of the jetty principle, that there is a direct and intimate relation between the velocity of the current and the amount of suspended sediment carried by it, so intimate, in fact, that the latter depends solely and entirely upon the former, if the depth and the local conditions remain the same.

It will be noticed, that, as the irregularities in the curve of the "material removed" become less marked, the twenty and thirty feet curves show less movement, especially during the last year, when the channel had more nearly attained its full development. An examination of the twenty and thirty feet curves, shows that the former has receded about one hundred feet and the latter advanced about one hundred and twenty feet, or in other words, that the outer face of the bar in December, 1879, was practically in the same position that it was in June, 1875.

The curve method of ascertaining the changes that have occurred beyond the end of the jetties is open to criticism, for it embraces only the one thousand feet immediately at the sea end of the jetties.

The second method, by which the difference between scour and deposit beyond the sea end of the jetties is obtained,

in cubic yards of material or in feet of depth, is more satisfactory. In making this calculation we shall confine ourselves to the area lying in the track of the river discharge. In elucidating the results we refer,

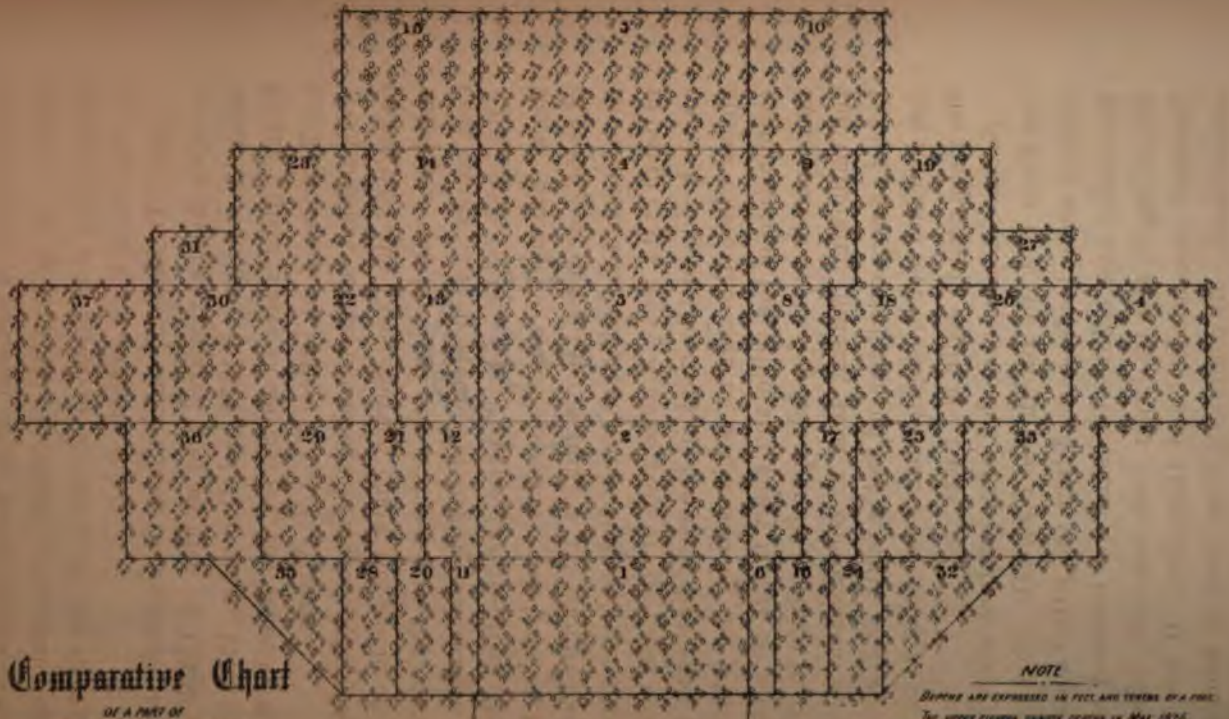
First.—To Plate 23, which shows the increase and decrease in depth that has occurred over an area of 178.53 acres between the surveys of 1875 and December, 1879, the former by the United States Coast Survey, the latter by the Assistant Engineer of the jetties, Mr. A. O. Wilson.

On account of the soundings being irregularly spaced, especially on the Coast Survey chart, the whole area was divided into one hundred feet squares and the soundings for each corner of each square obtained by calculation.

The table in Appendix 21 gives the result of the calculations. Taking the whole area into consideration, the excess of scour over deposit is one million five hundred and ninety-two thousand and fifty-five cubic feet, or an average increase in depth of 0.2 feet. A large part of the area, however, lies on each side of the track of the river discharge, and in the spaces where the current is checked by the jetties. By an examination of the table and chart it will be seen that the mean gain in depth depends upon its position in reference to the outflowing waters; thus in combination A, which embraces an area one thousand feet in width, and two thousand five hundred feet in length immediately in front of the jetties, the mean gain in depth is 1.1 feet; and

Second.—A more extended area has been surveyed at various times by Capt. Brown (see Plate 24). This area is fan-shaped, and extends seaward from the jetties about one mile. Its smaller base is three thousand five hundred and fifty-six feet in length, and its larger base, one mile distant, is nine thousand nine hundred and three feet. It has twenty-one subdivisions. By combining those that lie more directly in front of the jetties (viz.: seven to nineteen inclusive), and

PLATE 23.



Comparative Chart

OF A PART OF

Gulf of Mexico

COMPRISING

NOTE

Soundings are expressed in feet and tenths of a foot.

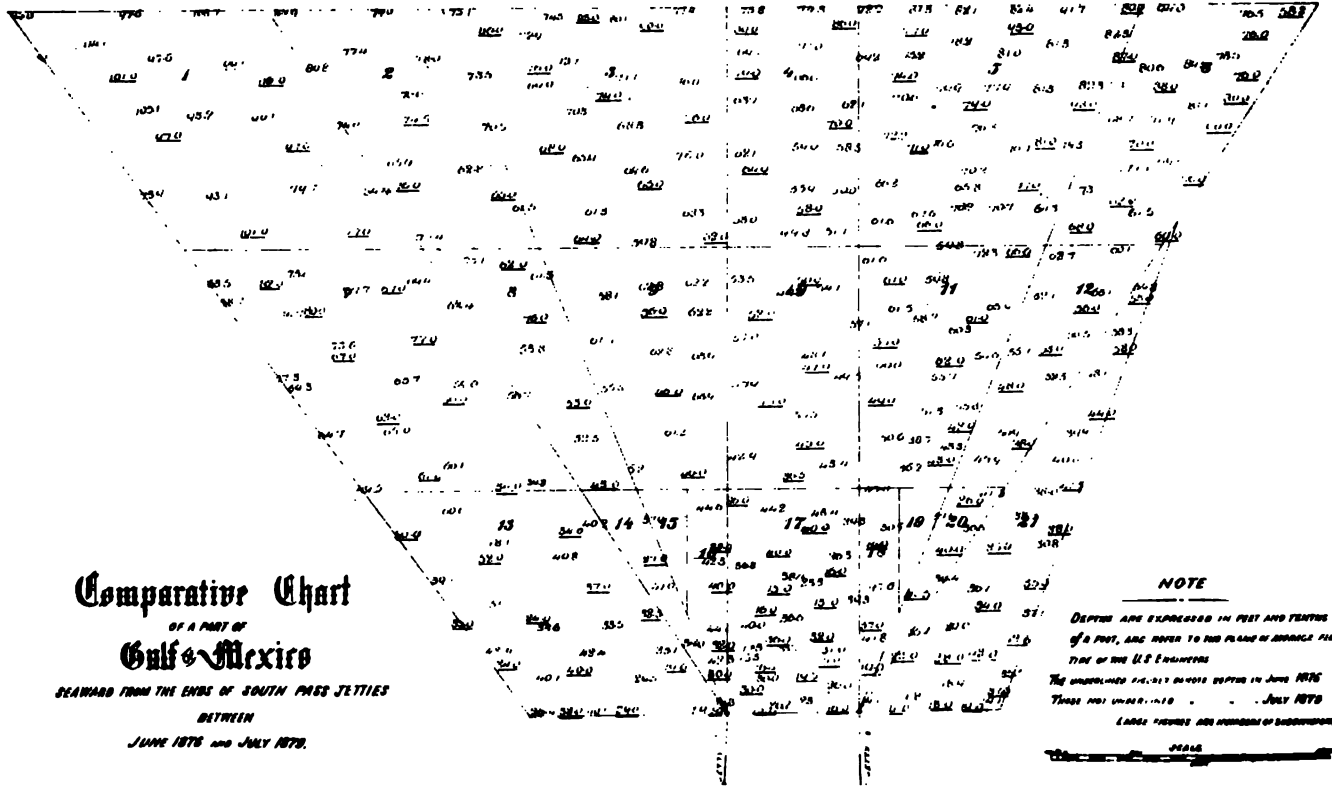
The upper figures denote depths in May 1876.

The lower " " " Dec. 1879.

Lower figures should accord the same place as upper figures — they are displaced for convenience in printing.

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PLATE 24.



Comparative Chart

OF A PART OF

Gulf of Mexico

SEAWARD FROM THE ENDS OF SOUTH PASS JETTIES

BETWEEN

JUNE 1876 and JULY 1879.

NOTE

DEPTHS ARE EXPRESSED IN FEET AND TENTHS OF A FOOT, AND REFER TO THE PLANE OF AVERAGE FLOOD TIDE OF THE U.S. ENGINEERS

THE UNDERLINED FIGURES DENOTE DEPTHS IN JUNE 1876

THOSE NOT UNDERLINED . . . JULY 1879

LARGE FIGURES ARE HUNDREDS OF SOUNDINGS

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making a comparison between the surveys of 1876 and 1879, we find an excess of scour over the whole area of one million and seventy thousand and eighty-seven cubic yards, and a mean increase in depth of 1.70 feet. The details of the calculation are given in Table 1, Appendix 22. On the chart the characteristic soundings only are given. If the subdivisions fifteen to nineteen inclusive are used as a basis for calculation, and the mean depths of the survey of 1879 are compared with those of the Coast Survey of 1875, we find a total scour of sixty-seven thousand one hundred and eight cubic yards, and a mean increase in depth of 0.63 feet. (See Table 2, Appendix 22.)

In June, 1879, Capt. Brown made a deep sea survey in front of the jetties extending to a depth of three hundred feet. A similar survey was made in August, 1876.

The soundings were taken on radial lines over a fan-shaped area, extending a considerable distance eastward of the jetties.

While the surveys will answer for an approximate comparison of results, the soundings do not give the exact depths for two reasons:

First.—The distance which the heavy lead sinks into the soft mud is a variable and unknown quantity.

After describing the method employed, which was that of an ordinary lead and line, Capt. Brown states in his report: "The results are as reliable as can be obtained, except by the slow and costly use of the accurate apparatus employed by the Coast Survey, losing an iron shot at each cast. Still it must be borne in mind that we have very little knowledge of how far the lead sinks into the bottom, and we know that this distance cannot be uniform over the whole area surveyed, and that it may not be quite the same in a certain locality at different times." (See Annual Report of Capt. Brown, June 30th, 1879, page 12.)

Second.—Cross currents exist in the gulf beyond the jetties, which are caused by the outflowing current of fresh water and the littoral or shore current of salt water nearly at right angles with it.

This salt water current, having a velocity varying from one to three feet per second, is sufficiently strong to sweep the lead line to one side, making it impossible to obtain accurate soundings. These currents are so variable at different depths and at different periods, that the ordinary methods of obtaining soundings cannot be relied upon in depths greater than one hundred feet. The comparison of the two surveys, considering five lines that nearly coincide in position, shows an average advance of the contours seaward of four hundred and ninety-five feet. On one of the five lines compared, the discrepancy between the two dates is so great that it ought not to be included. Two of the lines are far to the eastward and beyond the deepening influences of the jetties. The two remaining lines lie in the track of the river discharge; are nearly in the prolongation of the jetties seaward, and from their uniformity are alone capable of a fair comparison; they show, that instead of an advance of the contours seaward, there has been a recession landward of three hundred and forty-eight feet. Probably a greater recession would have appeared had both surveys been made at the same time in the year.

The channel results have been described and illustrated, extending from May, 1875, to July, 1879. From the latter date to the present time the channel has continued to improve. In several localities, especially between Station 6 and Station 100, where the twenty-six feet channel was but very little more than two hundred feet in width in 1879, and where the thirty feet channel was very narrow, the twenty-six feet channel has now a least width of two hundred and sixty feet, and the thirty feet channel has a least depth of thirty-

ne feet and a least width of sixty feet, with a width of three undred and sixty feet just inside the sea end of the jetties.

At the head of the passes a navigable channel twenty-six eet deep and one hundred and sixty-five feet wide was obained and certified to by Capt. Brown, on July 10th, 1879. Since that date the semi-monthly surveys show a constant increase both in depth and width. The twenty-six and hirty feet curves on the west side of the channel, above the lyke, have disappeared entirely. The thirty feet channel ow connects the deeper water of the river with that of the outh Pass, and its least width is over three hundred and ifty feet. The channel into the pass is straight and navigable for the deepest draught vessels.

Thus very nearly the same depths and widths of channel ave been obtained at the head of the passes and at the etties.

The bar at the head of South Pass, described in Chapter ., and which, with only fourteen feet of water over it, lay ike a formidable dam in the entrance channel, has been comletely removed, and the depth of water into South Pass is early two feet greater than that into the two larger passes n either side of it.

At the mouth of South Pass the current, which in 1875 truggled feebly against the frictional resistance of the bar hat obstructed it, became by the construction of the jetties a strong and living force, which, attacking the obstacle in its way, swept it far out into the great depths of the gulf, and carved out for itself a deep and wide channel more than equal to the wants of commerce.

CHAPTER XVII.

PERMANENCY OF WORKS AND RESULTS.

THE permanency of the results obtained in the channel through the jetties and in the gulf beyond them is a subject of paramount importance.

The jetties have been built; will they endure? The channel has been deepened; the bar has disappeared, and the whole sea-going commerce of the valley passes through the jetties. Are these beneficial results permanent? The sedimentary matters of the South Pass have for five years been swept so far out to sea that no trace of them has been discovered in front of the jetties. Will those conditions continue; and will the causes that produced them exist in the future in all their force?

Many of the reasons for the permanency of all these results have been given incidentally in the progress of the narrative. The wisdom in adopting the jetty plan has appeared all through the history of the work, and we believe that, if nothing further was said, the candid judgment of our readers would uphold us in the opinion that the results described are certain to be permanent. We will, however, state more fully the conditions existing in the river and the gulf, that affect the permanency of the works and their results.

The principal destructive forces to guard against are the gulf waves and river currents.

During their construction the jetties have at times suffered from the violence of the waves. On September 15th, 1875, a

ere storm visited South Pass. The wind was from the theast, with a velocity of fifty-two miles per hour. The es wrecked about one thousand one hundred lineal feet of ttresses that were floating in position along the east jetty ar Station 70, where they had been left for several days to k by accumulation of sediment in them. On December h, 1876, a violent storm from the southeast demolished eral of the temporary wing dams near the end of the jet-s. The waves lifted off and destroyed the top courses of mattresses on both jetties beyond Station 115. On Sep-ber 17, 1877, a storm reached the jetties, lasting three s. The maximum velocity of the wind was fifty-seven les an hour. Its direction at first was west southwest, n changed to southeast, and from that point veered around the north. A damage of about $1,200 was inflicted on the ties by loss of stone and shattering of mattresses. Three er violent storms subsequently visited the jetties, injuring some extent the top courses of mattresses. These storms re generally accompanied and followed by storm tides, ich raised the surface of the water from one foot to eigh-n inches above its ordinary level. These losses and dam-s occurred during the incomplete state of the work, when erally the mattresses, loaded with stone sufficient only to k them, presented an unprotected vertical face to the ves. Since the construction of suitable slopes of mattress, k, and crib work around the sea ends of the jetties, and the ilding of the massive blocks of concrete, there has been loss nor damage, although several violent storms have ought a terrific wave force against the works.

The height of storm waves at the mouth of the Mississippi from twelve to fifteen feet, measured from trough to crest. eir force is considerably broken by the long gradual slope, er which they travel before reaching the crest of the bar.

No danger from undermining of the jetties by the river cur-

rent need be apprehended, for by the construction of the wing dams, the channel has been located at a distance from the jetty walls and nearly midway between them. The tendency has been and will continue to be, to form deposits back of the wing dams, and along the river side of the jetties, which will remove the strong currents still further from the permanent works. But even without the assistance of the wing dams the channel would have been formed nearly midway between the jetties, or at least such would have been its permanent location. The same causes that formed the sloping banks of the river and passes, and placed the deepest part of the channel equally distant from the banks, where the course of the current is straight, would have accomplished the same result in the jetty channel, with the bank on the east slightly steeper than that on the west, owing to the curvature of the jetties. The currents near the jetties, slowed by the friction of the rough mattresses and by the bottom in the shoal water near the works, would have dropped their sedimentary matters near the jetties, and thus still farther increasing the velocity of the current in the centre of the channel, would have slowly deepened it. The wing dams hastened a result that natural causes would have produced, so that when these temporary structures are allowed to go to decay, the normal forces of the river will not only preserve the present form of the channel, but still further reduce the depth of water near the jetties and increase it at a distance from them, and gradually rectify any irregularities in the channel alignment that the wing dams may have produced.

Another destructive element, to which works built along Southern sea coasts are generally subjected, is the "Teredo Navalis," or sea worm, which lives upon unprotected woodwork.

Captain Brown's examinations of willows obtained on the

sea side of the end of the east jetty, from a depth of about eighteen feet, show, as he states, that the teredo enters the willow stick when young through small holes no larger than the puncture of a pin, and works along through the willow lengthwise with the grain. "The avenues made by the worms finally leave the willows a compact mass of nearly parallel tubes, lined in many places with a calcareous substance * * * much like a thin shell. This seems to lend some degree of toughness and strength to the damaged wood. * * * Where considerable sediment has settled on either flank of the jetties, the mattresses are mostly filled with mud and sand, * * * and all specimens of wood I have seen, known to have been completely buried in the mud, are entirely free from worms or their traces."

The reports of the Boards of 1877 and 1879 confirm the opinion of Capt. Brown, that the teredo cannot penetrate into the body of the work, and they say: "The teredo does not attack wood where the free access of sea water is impeded. Those portions of a stick buried in mud or sand, or packed around with mud or sand, are secure. We have no reason to believe that the teredo has penetrated or can penetrate far into the interior of the mattress courses; we have pretty good reason to believe that the foundation matresses are and will remain secure; and probably also the bulk of the interior of the masses of willow work." (See Appendix 18.)

The subsidence or settlement of the jetties, especially at their sea ends, is a subject of considerable importance.

It is evident from the record of the pile driving, given in Chapter XII., that from the land's end to the crest of the bar, any settlement recorded must be due to compression of the mattress work.

Beyond the crest of the bar, where more recent deposits had taken place, there is no doubt that during the earlier

stages of the work the foundation mattresses, on account of the superposed weight of other mattress work and stone, settled several feet into the foundation of mud on which they rested, and it is possible that the foundation itself also settled from compression.

Capt. Brown, in his report of July, 1877, speaking of the end of the east jetty, which he says until lately had been gradually sinking into the soft bottom beneath it, says: "The former rapid rate of settlement has intermitted, at least, and its cessation may be permanent." In his report of May, 1878, he states that in five and a half months the subsidence of the jetties is about six inches. In his report of June 30, 1879, he stated that the concrete blocks seemed to be sinking at an average rate of from six inches to one foot yearly, but that it was difficult to ascertain how much of this settlement was due to condensation of the mass of the work, and how much to other causes.

Levels taken by his assistants every month since the construction of the concrete blocks show, that between Station 103 and the end of the east jetty, the average settlement in ten months was about five and one-half inches. The least amount of subsidence of any one block was two inches, and the greatest amount eight inches. On the west jetty the average amount in nine months was four inches, the least three-quarters of an inch, and the greatest eight inches.

The least subsidence of three-quarters of an inch occurred about four hundred feet from the sea end of the jetty.

The irregularity in the degree of settlement in the blocks of both jetties, shows that the subsidence is caused mainly by compression of the mattress work, and not by its sinking into the foundation on which it rests, nor by the subsidence of the foundation itself, for if either of the two latter were the causes, the settlement of the blocks would be uniform, or at least in a gradually increasing ratio toward

the ends of the jetties. (The amount and rate of subsidence of the concrete work is shown in detail in Appendix 23.)

Thus we see that the four destructive forces to which the jetties are exposed, namely, gulf waves, river currents, the teredo, and subsidence of the works, have not seriously affected them during their construction and while incomplete and unprotected.

The expected increase in the volume of water flowing through the jetties will serve not only to perpetuate the results obtained, but even to enlarge the channel. The full normal section is not yet obtained. The average area of the section of the pass above Grand Bayou was, in 1875, about twenty-four thousand square feet. The present minimum section of the jetty channel is twenty thousand square feet. After the contraction of the entrance channel at the head of the pass, there was during two years a gradual contraction of the channel between the head of the pass and Grand Bayou. Since 1878, the increase in the volume entering the pass, due to the continued enlargement of the section between the dykes, has not only prevented further contraction, but has commenced an enlargement. The enlargement of the section of the pass below Grand Bayou has been progressive since the construction of the dam across that outlet. This is shown very clearly by the annual surveys of the pass by Capt. Brown.

The average depth of scour over the whole width of the pass during the four years between June, 1875, and June, 1879, was 1.13 feet, and the amount of the material removed was seven hundred and thirty-seven thousand five hundred and thirty-six cubic yards.

The area of section in the jetty channel will, no doubt, eventually be fully equal to that of the pass above Grand Bayou. Mr. Eads and Sir Charles Hartley have from the first contended that the channel through the jetties will be

even larger than that of the pass itself, and, in support of their opinion, allude to the effect of the jetties at the Sulina mouth of the Danube, which, though six hundred feet apart, have produced a depth greater than that which exists in the pass, where the banks are but four hundred and fifty feet apart.

The conditions at the mouth of the South Pass are still more favorable on account of the tidal flow, which sometimes at the bottom attains a velocity of 1.5 feet per second, when flowing in, and a much greater velocity when flowing out.

The constant deposition of sediment, which has been going on since the work commenced, will no doubt continue until the embankments against both sides of the jetties have everywhere, except at their extreme sea ends, reached the height of average flood tide. This natural action, with the artificial embankment of gravel, that has been placed above the datum plane on the slope of rubble stone and against the concrete blocks, will make the whole work impervious, and render the jetties as tight as the earthwork of the best reservoir embankments.

The enlargement of the channel during the last ten months is shown by the fact, that during the first five months after the maximum channel was obtained, the channel was reported by the inspecting officer to be deficient thirty-one days either in width or in depth, but during the second five months not a single day. There is every reason to anticipate a channel much wider and deeper than now exists. The restoration of the normal conditions at the head of the passes; the inflow of a greater volume of water; the permanent closure of Grand Bayou; the final imperviousness of the jetties, and the maintenance of these favorable conditions by the stability of the jetties and auxiliary works, insure for the future a channel whose dimensions will be much beyond the requirements of the law.

In discussing the permanency of the results obtained in the gulf beyond the jetties, it will be necessary to understand,

First.—The natural conditions that exist at the mouth of the South Pass, and

Second.—The new conditions that have been introduced by the construction of the jetties.

The natural process and order of bar formation at the mouths of the passes have been described in preceding chapters, in the description of the delta and in the discussions of the causes that produced the bars. At the mouth of South Pass the conditions differed in some respects from those of the two larger passes. The volume of its discharge, and consequently that of its sedimentary matters, was much smaller; the slope of the outer crest of the bar was much steeper, and the mud lump formation had nearly ceased.

The bars at the mouths of the two great passes are largely composed of mud, while the bar at the mouth of South Pass is of hard sand. The cause of this difference is to be found in the fact that the power which wave action gives to sea water to suspend sedimentary matters decreases with the depth.

If we assume any given area, say one mile square, in front of either one of the passes, it is fair to assume that for equal depths the waves give to the water over such area an equal power to sustain the sediment. The lesser depth formerly existing at South Pass would give a greater power of suspension than that which the water possessed over the bars at the greater passes.

The Southwest Pass discharges about four times the volume of the South Pass; therefore the wave action at the Southwest Pass is less able to hold up in suspension and leach out the lighter or muddy portions of the sediment discharged by the river. At the South Pass this leaching out process being thoroughly accomplished, the sand alone re-

mains to form the bar, the lighter portions having been swept far out to sea.

The existence of a littoral or shore current at the mouth of South Pass, which has been most emphatically denied by the opponents of the jetties, is clearly proven by the following facts:

In February, 1875, Prof. Henry Mitchell, of the United States Coast Survey, made observations to decide this question. At the date of these observations the weather was calm with a slight breeze from the north. He established one section across the pass at the lighthouse, and another about two thousand two hundred feet in length in twenty feet of water, immediately beyond the crest of the bar, and parallel with the face of it. Careful gauging of the volume passing through these sections gave twenty-three thousand five hundred and forty-seven cubic feet per second at the lighthouse and one hundred and seven thousand five hundred and ninety-six cubic feet per second at the section outside the bar. This was more than four times as much as the former, although a considerable portion of the volume had escaped laterally over the outlying reefs before reaching the crest of the bar.

The average velocity, from surface to bottom, was thirty per cent. greater than that at the lighthouse, and the maximum velocity of the six feet depth was one hundred per cent. greater. A deflection of the current to the westward was noticed. These observations proved the existence at that time of either a littoral current or a race of the sea. (See U. S. Coast Survey Report, 1875, Appendix No. 11, page 189.)

On May 27th, 1874, Mr. Bayley published a letter in the New Orleans *Picayune*, in which he gave some facts relative to a littoral current. He referred to the captains of steamships and to the experience of fishermen, to prove that there is a regular coastwise westerly current, except only when temporarily checked by westerly or southwesterly gales, and that

steamers make better runs westward than eastward. He referred to the Coast Survey report of 1853, to show that important changes at the Grand Pass entrance to Barrataria Bay were caused by the strong westerly currents of the gulf. He says further "modern current charts correctly represent the great equatorial current, as sweeping in its resistless course around the Gulf of Mexico, across and near the mouths of the passes, and that an eddy current commences there and flows westward along the Louisiana coast."

Observations and experience during the construction of the jetties show that the shore current which exists there is not always westward, but under the influence of westerly winds, has sometimes been found to be quite strong to the eastward.

On March 13th, 1878, Captain Brown found a current of three feet per second at the bottom, moving to the eastward. The location of his observation was six hundred feet beyond the end of the jetties, in twenty-eight feet depth of water. The surface current of fresh water was moving straight out. But the prevalence of the westerly current, which is doubtless due principally to the prevailing winds, is shown by the fact that the drift logs of the Mississippi River, drift lumber from the jetties, and the buoys along the delta that break from their fastenings, are found invariably along the coast of western Louisiana and Texas.

We have thus given the natural conditions, as far as relates to bar formation, wave force and current action. The jetty construction has, however, brought with it the following new conditions:

First.—Where there was formerly a sluggish river current about eight feet deep, there is now at flood river a swift current over thirty feet deep; and

Second.—The protrusion of the jetty walls into the salt water currents has greatly increased them on the same prin-

ciple that a dyke built out into a river current will greatly increase its velocity opposite the end of the dyke. The strong volume of fresh water flowing out of the jetties cannot be thrust aside at once by the cross current of salt water, nor can the volume of salt water sweeping with great force past the end of the jetties be held back by this volume of fresh water, which, like a great obstruction, is thrust out into it. The result of these two forces, meeting at right angles nearly, is a depression of the salt water current into the unstable gulf bottom, and a consequent scour and removal of the material to restore the sectional area. This action at high river nearly counterbalances the depositing action, and during low river the quickening of the gulf currents caused by the jetty walls projecting into the sea, is shown by the marked deepening that always occurs at such seasons, and by the invariable recession of the face of the bar. The influence of the new conditions created by the works of improvement upon the outlying ridges, shoals and lumps was very clearly exhibited by two models prepared in plaster for the Paris exposition of 1877, by Mr. Schmidt. These models represented the condition of the South Pass bar in 1875 and 1877 respectively. The marked elevations existing at the former date beyond the crest of the bar, had been leveled and reduced in all their dimensions by the deeper flowing volume of the river and the stronger cross currents of the gulf.

Thus the leveling and disturbing influences of the waves, and the eroding influences of the salt water currents and the river floods, have for five years prevented an advance of the bar. In place of pushing the bar into the gulf at the rate of six hundred feet per annum, or a total distance of three thousand feet, as was predicted by Gen. Humphreys, the jetties have not only cut the bar entirely away and stopped its advance, but have deepened the gulf beyond them.

The commercial benefits obtained by the construction of the jetties have been no less marked than the natural results.

Five years ago the vessels, when loaded to eighteen feet even, were with great difficulty towed through the narrow ditch dug by the government dredges at the mouth of the Southwest Pass, or were delayed for days while the bar was blocked with other vessels. Now the *Great Eastern* can pass in or out with safety. A record of the navigation of South Pass is given in Appendix 24. A study of this table shows the following: namely, that since the opening of the pass to navigation in 1877, and the discontinuance of work by the government dredge boats at Southwest Pass in August of that year, there has been a considerable increase in the number of vessels crossing the bar, especially of steamers, and also a great increase in draft.

The steamers increased in number from five hundred and eighty-seven in 1877, to eight hundred and forty in 1879, and the number drawing from twenty to twenty-four feet increased from eleven to one hundred and thirty-four in the same period, of which number fourteen drew twenty-three feet and over. The maximum draft of 24′ 6″ was that of the steamship *City of Bristol*, of the Inman Line, on October 31st, 1879.

The increase in exportation from one source alone may be seen by the following extract from the annual statement of the "Trade and Commerce of St. Louis" for the year 1879 reported to the Merchant's Exchange of that city. "Direct shipments to foreign countries from St. Louis, in tons, by rail through the Atlantic ports, and by river through New Orleans:

	1879.	1878.	1875.
Total, in tons, by rail.....	135,881	72,091	16,825
Via river, to New Orleans to Europe	176,531	154,060	6,857

This statement shows that the *increase* in exports via the mouth of the river is three times greater than that by rail to the Atlantic seaboard in the time mentioned.

The benefits that have accrued already to the agriculture and commerce of the Mississippi Valley are clearly shown by the following extracts from a letter dated New Orleans, La., May 28th, 1880, and addressed to the author by Gen. Cyrus Bussey, an eminent merchant and President of the Chamber of Commerce of that city, and one of the early friends of the jetty enterprise:

"Since the completion of the jetties there have been no complaints of detentions at the mouth of the river. Vessels of the largest class pass through the jetties fully loaded without touching the bar; to illustrate, reference is called to the steamship *Australian* which sailed from New Orleans, May the 11th, drawing twenty-three and a half feet, with a cargo of four million and eighty-six pounds, equivalent to eight thousand two hundred and twenty bales of cotton.

"During the month of May vessels drawing twenty-three and one-half feet have *arrived* at this port, bringing large cargoes of merchandise, which have greatly increased the value of the imports at the port of New Orleans since the completion of the jetties. The effect of the jetties on the transportation lines of the country cannot yet be estimated; that the effect has been to lower the rates on all transportation routes from the Mississippi River to the seaboard, cannot be denied. Prior to the construction of the jetties the commerce between New Orleans and foreign countries was carried on by vessels which could not load deeper than eighteen to nineteen feet, and then they ran great risk of detention for an indefinite time before getting to sea. These facts prevented many vessels from coming to this port; those that did come demanded and received high rates of freight, five-eighths penny to seven-sixteenths penny per pound for cotton to

Liverpool, and twelve pence per bushel for grain. During the past season the rates have been one-quarter penny to three-eighths penny per pound for cotton, and seven pence per bushel for grain, while the exports have been largely increased, amounting to over one million seven hundred thousand bales of cotton against one million four hundred thousand last year, while the shipments of grain have more than trebled those of the year 1878, and are rapidly increasing.

"Large fleets of barges are being built to carry grain from St. Louis and other points on the Mississippi River to New Orleans; while at this port the facilities for handling and storing grain are being greatly increased; floating elevators of immense power are being constructed, while new elevators of very large capacity are to be constructed on land; the large elevator which stood empty for years before the jetties were constructed, is now full, and there is a demand for storage capacity equal to half a million bushels, which cannot be supplied.

"The low freights made possible by the jetties have effected this large increase in the exports from this port. The saving on the freight on the cotton, grain, cotton seed, oil, oil cake, and other articles, including staves, etc., exported from New Orleans for the year ending 31st August, 1880, will exceed $4,000,000 over the freights that would have had to be paid, if the jetties had not been constructed. This is not the only saving; there has been a reduction in the rates of insurance, and a perceptible saving in time, which is an important consideration, as the value of the cargo of a ship is on interest until it is delivered to the consignee and sold. There being no longer any detention on the bar at the mouth of the river, we hear no complaints of heated cargoes of grain arriving in foreign ports from New Orleans. The good character of the grain shipments from this port is fully established. If, in addition to other advantages, we consider

the reduction in freights on the river transportation, caus
by larger cargoes being carried, owing to the increased d
mand caused by the jetties, we may safely estimate that t
sum saved to the producers in the Mississippi Valley, on th
portion of their productions finding a market through Ne
Orleans, amounts to five million dollars annually. The val
of the jetties to the commerce of the whole country cann
be estimated."

Not only should the reduction of freights on products th
are shipped via New Orleans be credited to the jetties, b
also on all those products whose natural route to market
by the Mississippi River, but which find their way to t
Atlantic seaports by the various railway lines, for they ha
been forced by the jetties to reduce their rates to compe
with those of the river. Therefore, the annual saving as e
timated by Gen. Bussy as resulting from the jetties shou
be largely increased.

"Westward the star of Empire takes its way." Alrea
three-eighths of the whole cotton crop of the United States
grown west of the Mississippi River. In 1849 the center
the wheat-growing belt was east of Cleveland, and that of t
corn-growing belt between Cincinnati and Louisville.

At the present time the center of both belts is *west* of t
Mississippi; the production of wheat reaching now abo
400,000,000 bushels per annum, and corn about 1,500,000,0
This westward movement of the grain center increases t
cost of transporting the grain to the Eastern ports by r
and draws these immense productions toward their natu
outlet to the world, *via* the Mississippi River.

These natural and inevitable tendencies of agriculture a
commerce have already accomplished the improvement
the mouth of the river, and they now demand the removal
all obstructions in this great commercial highway of t
nation, from New Orleans to St. Louis.

CHAPTER XVIII.

CONCLUSION.

As this history draws to a close, it is proper to mention those who have been the friends of an enterprise, that by overcoming all financial and natural obstacles, has accomplished results of such great importance to the country.

The record commences with those to whom this work is dedicated. In no legislation during the past ten years has the wisdom of our lawgivers and the executive officers of the government been more clearly shown, than in the enactment and execution of those laws that pertain to the work that has given the commerce of the Mississippi Valley an OPEN RIVER MOUTH.

Among the merchants, bankers, capitalists, manufacturers, and others who assisted the enterprise in various ways, stand out prominently the individual associates of Mr. Eads and the stockholders of the South Pass Jetty Company, who invested their money in the jetties at a time when they were considered a doubtful experiment, and who were willing to trust to the success of the enterprise for the return of their investment.

The civil engineers of America and Europe, with a few exceptions, favored the jetty plan and gave it their hearty support. The members of the American Society of Civil Engineers, especially, evinced a deep interest in the work, and visited it during their annual convention at New Orleans in 1877. They, above all others, have reason to honor the

illustrious member of their society who, in Congress, gained for them a signal victory by establishing the precedent of intrusting our national hydraulic works to civil engineers, who are especially fitted by education and experience for the discharge of such important duties.

The laborious scientific investigations of Capt. M. R. Brown, United States Inspecting Officer, constitute a valuable contribution to the science of civil engineering, and while they reflect credit upon the patience and skill of that officer, they furnish proof of the correctness of those theories upon which the expectation of the success of the works was based.

Though a great sufferer from health impaired on other works, he performed faithfully for four years the duties devolving upon him. He died at his home in Lawrence, Mass., April 10th, 1880.

During his long and enforced absence at various times, the surveys and office work were intrusted to Mr. C. Donovan, his chief assistant, whose experience and good judgment especially fitted him for the peculiar and difficult position in which he was placed.

The author, as the resident engineer, desires to place on record the efficiency and faithfulness of his own Engineer Corps—Max E. Schmidt, W. Leslie Webb, W. S. Morton, H. W. Parkhurst, F. A. Gladding, A. O. Wilson, and Willard Lawes—whose zealous interest in the performance of their duties greatly lightened his own labors and responsibilities.

In closing this record of honorable mention we allude briefly to the employees, who by arduous and faithful labor established a claim to high regard. The list of their names, which, if space permitted, might be greatly extended, is given in Appendix 25, that wherever this record of a great work goes, it may be known whose faithful labor performed the work that has accomplished such beneficial results.

More than to any other person engaged in the construction

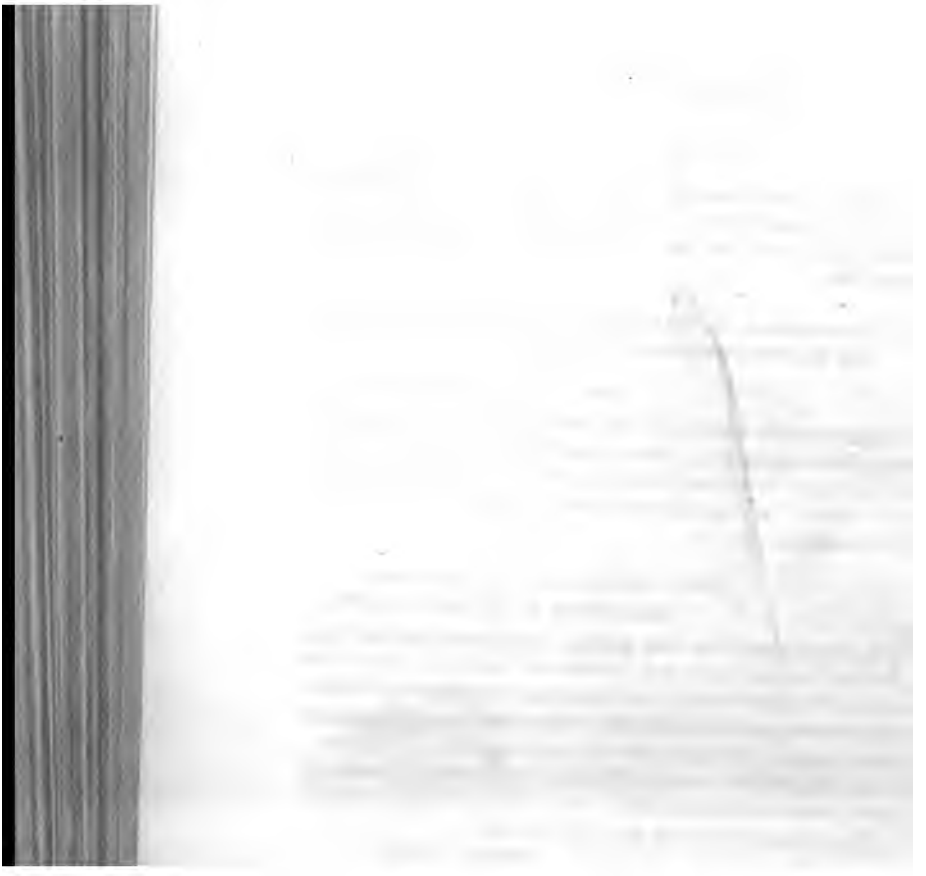
the jetties are indebted to Mr. James Andrews. He not only embarked his private fortune in the work, and aided it by his knowledge and long experience on public works, but with a remarkable energy he pushed it forward to completion. Through all the vicissitudes of the work, often disheartening, he preserved not only a steadfastness of purpose and an integrity of character, but such a persistent determination to achieve success in spite of all opposing influences, that he inspired and maintained confidence in the minds of all his associates in the enterprise, and thus contributed most efficiently to its successful issue.

However great the praise due to others, too high a tribute cannot be paid to James B. Eads, who conceived the jetty project and secured its adoption, and to the triumphal completion of which he so earnestly devoted himself.

The deep and permanent channel at the mouth of the Mississippi River is an imperishable monument to his genius.

With a few words to express our utmost confidence in the principles which have been demonstrated by the works we have described, and whose success we have chronicled, we close this history of their construction.

In a score of centuries the South Pass jetties may be buried beneath the vast deposits, which the river floods will accumulate upon and even beyond them, as the delta advances into the gulf, and it may be necessary for some generation in the distant future to repeat the work of this; but the *jetty principle* has been so clearly proven to be in perfect harmony with the laws of nature, that either at the mouth of the South Pass, or some pass of the Mississippi River, jetties will be maintained forever. So long as the husbandman tills the soil of the great valley, so long shall he find for his productions a natural highway to the world through an *open river mouth.*



APPENDIX.

APPENDIX I.

(See page 21)

XTRACTS FROM REPORTS UPON FORT ST. PHILIP CANAL AND CONSTRUCTION OF JETTIES FOR THE IMPROVEMENT OF THE MOUTHS OF THE MISSISSIPPI; BEING APPENDIX R (IN PART) OF THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1874.

Report of Board of Engineers on the improvement of the passes as an alternative to, or in connection with the canal.

NEW YORK, *January* 13, 1874.

The Board of Engineers convened by Special Orders No. 83, headquarters Corps of Engineers, Washington, D. C., dated June 30th, 1873, to report upon the project of a ship-canal to connect the Mississippi River with the deep waters of the Gulf of Mexico, having had the matters referred to them extended by the following instructions, viz.:

OFFICE OF THE CHIEF OF ENGINEERS,
WASHINGTON, D. C., *October* 3, 1873.

SIR: In reply to your letter of the 24th ultimo, I am directed by the Chief of Engineers to say that it is allowable and desirable to have the views of the Board of Engineers on the question as to the expediency of improving the navigable outlet of the Mississippi, by the Fort St. Philip Canal, as an alternative to, or a simultaneous measure, perhaps, with the improvement of the passes.

The report of Capt. Talcott, of January 30th, is in the hands of the copyist, and will be furnished you as soon as possible.

Very respectfully your obedient servant,

JOHN G. PARKE,
Major of Engineers;

Col. J. G. BARNARD,
Corps of Engineers,

have the honor to submit this report:

The improvement of the passes has usually been discussed in reference to the application to them of the jetty system, or of dredging, in conjunction

with each other, or separately, and the board propose to confine their attention to these methods.

The depth of water over the bar to serve for commercial, naval, and military purposes, it is assumed, should be the same as that selected for the draught over the miter-sill of the proposed ship canal, viz., twenty-five feet at extreme low water of the gulf. The pass to be improved is assumed to be Pass à Loutre; this having been selected by several engineers advocating the improvement of the mouths of the Mississippi as the best adapted to the application of the jetty system.

In order to advance the low-water twenty-five foot curve of the channel of the pass from the point where this depth ceases to obtain to the bar, it would be necessary to construct parallel jetties, of the same distance apart as the shore-lines of the pass where the required depth is excavated.

These considerations fix the length of each jetty at about twenty-four thousand feet, and the distance apart two thousand two hundred feet.

The top of the jetties must be held low, not higher than the banks from which they extend, because additional height, while adding to their cost, would not induce the passage of more water between them so long as the banks of the river above are at a lower level. An elevation of the jetties above the banks from which they spring would, in fact, endanger the latter in the presence of a rise overtopping them, especially at the points where the jetties and banks unite.

The debouch of Pass à Loutre by two mouths makes it necessary to close one of them, and this operation is supposed to be performed by the north jetty, constructed across the northern mouth.

An inspection of the map of the pass, to fix in the mind the necessary course of the northern jetty, will show that the present direction of the running waters will be deflected by this work, which forms a concave bend to receive them, and a considerable scour of the bank must necessarily ensue, causing the foundations of the jetty to be undermined, unless effective measures are taken to prevent such catastrophe.

The Board are unable at this time to suggest any remedy except to sink the foundations deep enough to be out of reach of these influences. As to how great this depth should be to insure safety, the Board have no certain means of judging, but it may be twenty-five feet, or even more.

The closing of the northern mouth, which, following the line of jetty would be a work operating to deflect the present direction of the currents, and over seven thousand feet in length, is an undertaking of great delicacy, the cost of which, in a soil of the character pertaining to this locality, might prove to be excessive. Success in this operation is, however, necessary to the application of the jetty system to the pass under consideration, and must be sought at whatever cost, in order to accomplish the desired improvement of navigation. It is important to say that the advance of the jetties, step by step, will cause deep holes to form at their extremities, due to the escape of the waters as soon as released, and a consequent excavation of the loose soil, which will much increase the depth and cost of these works.

The dislodgment, by the operation of the jetties, of the immense quantities of material from the sides and bottom of the channel would bring the scouring force into contact with the interior of the banks and shoals, which consist gen-

rally of soil inferior in hardness and firmness; and it would be impossible so o fix the limits of this disturbing action that it might not often reach the jetties themselves.

The long, low banks and the shoals of the delta do not owe their existence or permanence to anything inherent in the strength and consistence of the soil composing them—for on these points all testimony agrees—but upon the action of the waves and currents, constituting an area of equilibrium, in which the particles are deposited and retained.

But as these forces are not always as to effect, but only periodically, in equilibrium, it necessarily follows that changes in the shoals and banks are constantly occurring, not enough, indeed, to interfere with the general development of the delta, which appears to advance by virtue of uniform laws, but quite sufficient to endanger and even destroy the most skillfully designed works.

This consideration of the unstable and treacherous nature of the shoals and banks is necessary in order to fix the mind upon the cost and risk as well as upon the disappointment which would likely attend an attempt, upon such foundations, to construct works to coerce or control the currents of the passes.

An estimate has been prepared by Capt. Howell, engineer in charge of the jetties described in this report, supposing them to rest upon the natural bottom, without settlement, as follows:

Fascines and ballast, at $5 per cubic yard	$2,545,220 00
Riprap stone, $7 per ton	2,241,097 60
Total	$4,786,317 60

If settlement and the other probabilities enhancing the cost of this work, as already discussed, be considered, it appears entirely within limits to state that the above estimate should be doubled.

Assuming that it will take about four years to complete the jetties to the present twenty-five-foot curve outside the bar, and estimating the least yearly advance of the bar at two hundred and fifty feet, it would be proper to add to the estimate already the cost of two thousand linear feet, equal to $68,888.

There is, besides, the estimate for future annual extensions to keep pace with an increased advance of the bar, which by the same authority would be $1,613 per linear foot of jetty.

The next step in order is to consider the effects of these jetties, supposed to terminate at the curve of twenty-five feet outside the bar, upon the depth of water in the channel and upon the bar; and it will be first supposed that the jetties, if projected too far apart, should near the bar be brought together sufficiently close to insure the desired scouring effect upon the bar.

Would this state of things, thus produced, endure for a considerable time, or for a period sufficient to fill up the deep space ahead in the gulf to a distance equal to the present interval between the termination of the twenty-five-foot curve in the channel and the outer crest of the bar?

The principles upon which a reply to these questions depends have been exhaustively treated in Chapter VIII of Humphrey's and Abbott's Report on the Physics and Hydraulics of the Mississippi River; and there is nothing more to add, except the conclusions which follow from that report.

Let us suppose, as the first effects of the jetties, the twenty-five-foot curve

to have advanced to the original outer crest of the bar. It will be found that the position of the crest has already advanced, due to the large amount excavated from the sides and bottom of the channel, and the ordinary supply of materials which are rolled on the bottom and deposited on the outer slope; and it is not certain that there would be a full depth of twenty-five feet at the new crest, on account of the tendency to form the upper surface of this deposit coinciding with the angle at which the river waters emerging from between the pier heads would be deflected upward by the waters of the gulf, an effect which the spread of the river waters, after their release from the confinement of the jetties would increase. The succeeding flood, while advancing the bar, should upon the same principles, still further decrease the depth over its outer crest; and every advance of the bar would be followed by a similar result. Hence the jetties, in order to retain the depth gained, should keep pace in their extension with the progress of the bar. At high water of river, the deposits are made exteriorly; at low water, interiorly. During the changes from high to low water, the deposits are made between these two, or on what is ordinarily considered the bar.

A condition of things likely to occur periodically, whereby a medium stage of the river, without high floods, might be maintained, would cause unusual deposits upon the bar; and hence an additional reason for the conclusion, apparent already from the first portion of this discussion upon the bar, that in order to secure, at all times, a depth of twenty-five feet, provision should be made in the arrangement of the jetties to excavate to a depth greater than that. * * * *

The difficulties at the mouth of the Mississippi, so far as concerns the improvement by jetties, resolve themselves into three sources :

1. The absence of a littoral current.
2. The yielding nature of the banks and shoals.
3. The abundance of deposits.

The first and third combine in the yearly and rapid extension of the bar, and compel the works of improvement to continue at a heavy annual cost until their entire abandonment.

The second makes their construction difficult and their maintenance improbable, unless deeply founded at a very heavy expense.

All the principal objections to the improvement of Pass à Loutre necessarily apply to the Southwest Pass. * * * *

Upon a review of the practical difficulties which the adoption of the jetty system of improvement at the mouth of the Mississippi would entail, and a due consideration of the original cost of construction and of annual extension, entertaining doubts, moreover, of the successful issue of the attempt, the Board does not consider it advisable to recommend it.

With regard to the cost of this operation, owing to the uncertain nature of the problem, made so by the peculiar risks attending it, the Board find it impossible to fix any reliable limits.

The estimate in this report, made upon a hypothesis favorable to the project, indeed, but which does not exist, is useful only to convey to the mind some idea of the magnitude of the undertaking.

As an auxiliary to the improvement by jetties of the mouths, dredge-boats must be employed to remove mud-lumps.

The other means of improving the depth at the mouths, by the stirring-up process, has already been put to the test of practice. * * *

The effect of the stirring-up process is to sift out the finer, leaving on the bottom the heavier, sandy particles, thus forming a surface harder than the natural one of the bar. Nevertheless, vessels pulled with powerful tugs are drawn through with a draught greater by one foot than the depth of the channel. This operation would not generally succeed with long, sea-going steamers.

The results so far do not warrant the Board in estimating a greater depth than eighteen feet at extreme low water as capable of being maintained at the passes by means of the stirring process. This is inadequate to the requirements of the naval, military, and commercial services.

Although the stirring-up process cannot, therefore, be made a substitute for a project affording the proper depth, it should be continued until such project shall have been completed.

It is understood that one member of the Board of 1852—Maj. Chase (now deceased)—was in favor of the canal project, (Note D.) Another member, Maj. Beauregard, has expressed his opinion very emphatically in favor of a ship-canal, and doubtfully as to the jetty system. This testimony is valuable, as springing from the matured judgment of an experienced engineer, well acquainted with the subject he discusses, and is an evidence of a prevailing conviction which points to the fact that the time has come for obtaining an outlet to the ocean of depth sufficient to meet the necessities of the great valley of the Mississippi, and that the canal offers the best and most certain means of attaining this result.

JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Maj. Gen.
Q. A. GILLMORE,
Maj. of Engineers, Brevet Maj. Gen.
WM. P. CRAIGHILL,
Maj. of Engineers.
G. WEITZEL,
Maj. of Engineers, Brevet Maj. Gen.
C. W. HOWELL,
Capt. of Engineers, Brevet Maj.

Not fully concurring in the above, my views will be submitted in a separate report.

J. G. BARNARD,
Col. of Engineers and Brevet Maj. Gen.

Minority Report of Col. J. G. Barnard, Corps of Engineers.

* * * * * * * * *

In turning to the subject of jetties, I do not know how I can better define at the outset my position in relation to them than by quoting from the draught of a report which has been submitted to the Board, and which has already passed through your hands :

I can only reason on *probabilities* deduced from study of the river and the

lights of experience; and so long as to establish the negative there has been, I need not say, no *trial* of the system, but not even a survey accompanied with a careful study and experiments, directed expressly to develop the cost and character of the work needed, I feel that I am justified in recommending it as *probably* furnishing the most speedy attainment of a deep-water channel, and one which will have some features of permanence.

In a passage already quoted from the report of the Board of 1852, the *rationale* of the jetty system is explained. I further cite from the "Physics and Hydraulics of the Mississippi" the following:

"The development of the laws which govern the formation of the bars has removed all uncertainty as to the principles which should guide an attempt to deepen the channel over them. The erosive or excavating power of the current must be increased relatively to the depositing action. This may be done either by increasing the absolute velocity of the current over the bar or by artificially aiding its action. To the first class of works belong jetties and the closure of lateral outlets; to the latter stirring up the bottom by suitable machinery, blasting, dragging the material seaward, and dredging by buckets. These plans are all correct in theory, and the selection from them should be governed by economical considerations."

Such is the theory, and no engineer has yet expressed a doubt as to the fact that concentration of the waters of one of the passes by jetties carried out to deep water *would excavate the required deep channel*. The difficulty and the cost of construction, the alleged necessity of costly annual extension, furnish the arguments why this method should not be resorted to. While the general laws which govern the formation of bars at river-mouths are universal, there are peculiarities in the formation due to the natural differences of character of the rivers and of the sea-shore where the mouth is situated. If the shore be itself sand or gravel, and not rock, a bar always forms, whether the river brings down sediment or not. The latter material cannot, therefore, be regarded as in any sense the *cause* of the bar, though when it exists it is found to be the material of which the bar is composed. The most intractable bars are usually found to be of the former class; and yet, with few exceptions, every harbor on our northern lakes constituted by a river or creek mouth has been improved by the construction of parallel jetties. That those jetties need sometimes to be *prolonged* is no denial of their efficacy. * * *

On the other hand, the very rapid deepening of the Gulf immediately off the bars, and the favorable exposure of their external slopes to the action of the sea-waves and currents generated by easterly storm-winds, are circumstances decidedly favorable. Surely there is ground here, especially when we weigh the inestimable benefit of an open RIVER MOUTH, to pause at least long enough for a mature study and investigation, not merely on paper, but by surveys and measurement at the localities, to collect the special data which bear upon the application of the project to them, instead of, by a hasty pre-judgment founded on inadequate knowledge, deciding that there is *no* remedy to the evils *but* the gigantic and costly alternative of a ship-canal.

It is proper, however, to allude to the more prominent objections. One of them is based upon the following, from "Physics and Hydraulics of the Mississippi:"

"If the excavating power and depositing-action of the Southwest Pass had

ıal when the yearly advance of the bar was seven hundred feet instead
hundred and thirty-eight feet, the least depth upon it would have been
one feet. This increase of excavating power may be obtained by con-
g two converging jetties, beginning where the depth of twenty-two
found, and extended to that depth outside the crest of the bar, which
ive them a length of about 2.5 miles. * * * *
be depth of twenty-one feet thus obtained must be maintained by the
extension of the jetties seven hundred feet into the Gulf."
s dictum is founded upon a theory of bar-formation, which is doubtless
nd yet does not contain the whole truth; for were the Gulf waters fresh
same specific gravity as those of the river, there would still be a bar;
er, the stretching of any theory of so complicated phenomena to *nu-*
results is generally putting upon it more than it will bear. * * *
n not called upon to make a plan or an estimate. If successful at all,
have endeavored to show that success is promised,) the cost will be a
raction of that of the canal. On the other hand, the advantages of an
iver-mouth are inestimable. The needs of a navigation so great as that
now exists, and which in the future of the great Mississippi Valley
e fifty-fold increased, demand it.
s said, that "the time has come" when the needs of commerce demand
ıal; but I answer that the *time will come* when there will be the same
a navigation unimpeded by locks—AN OPEN RIVER-MOUTH—which we
ar for a canal. But in whatever aspect the question be regarded, the
the river-mouth for the next ten years is simply inevitable.
conditions of the location and execution of a canal have received no
te study. The plan, boldly and ably, yet so imperfectly, sketched out
forty years ago by one for seventeen years my commanding officer or
ional associate, W. H. Chase, is yet, in its engineering features, the best
xtant; and the grave objections to *that* apply with even greater force to
sent project, and demand new studies of location and an entire revision
is of execution. It would be a rash confidence which would contem-
realized "Fort St. Philip Ship-Canal" earlier than A. D. 1884.
the mean time shall the routes of commerce of the great West be yet
ffectually than now diverted to the Atlantic ports; or shall the public
nce be directed to the *present* adequacy of the operations upon the bars;
all the problem, which sooner or later *must come*, of an *open river-mouth*,
ed?
pectfully submitted.

J. G. BARNARD,
Col. of Engineers and Bvt. Maj. Gen., President of Board.
g. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Minority report of Maj. G. K. Warren, Corps of Engineers.

ENGINEER'S OFFICE, UNITED STATES ARMY,
NEWPORT, R. I., *January* 15, 1874.

NERAL: As a member of the Board of Engineers considering the Fort
ilip Canal project for connecting the deep waters of the Mississippi

River and the Gulf of Mexico, directed by you to also consider the alternative proposition of making this connection by deepening the water over the bars in the natural outlets, I beg leave to say that on this last proposition I do not feel possessed of the data for a detailed report, nor do I see how these can be obtained but by costly experience. Any conclusions reached now must unavoidably rest upon what is, in a measure, assumed, and opposite conclusions will be reached by others using the same liberty.

My mind, however, is fixed upon the idea that the canal is the only project that will meet the commercial, naval, and military demands of the United States. Its feasibility has never been doubted by any one, and only on account of its cost have other methods been heretofore recommended. These other methods have always been regarded as experiments, and the reliance has been that, if they failed, the canal, as a final resort, was certain.

I believe the time has come when that which appears certain should be tried first.

The cost of the canal will not be great compared with the end to be gained; and there is no certainty that we will not have to come to it after great delay and expenditure upon other methods, none of which, when abandoned, will have aided in the least toward constructing the canal.

Very respectfully,

G. K. WARREN,
Maj. of Engineers, Bvt. Maj. Gen. U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX II.

(See page 60.)

REPORT OF BOARD OF ENGINEERS RELATING TO IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER BY JETTIES; BEING APPENDIX S (IN PART) OF THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1875.

(General Orders No. 74.)

WAR DEPARTMENT, ADJUTANT-GENERAL'S OFFICE,
WASHINGTON, *July* 2, 1874.

Lieut. Col. H. G. Wright, Lieut. Col. B. S. Alexander, and Maj. C. B. Comstock, Corps of Engineers, United States Army; Professor Henry Mitchell, United States Coast Survey; T. E. Sickels, W. Milnor Roberts, and H. D. Whitcomb, are, by the President, hereby appointed a board of engineers under provisions of section three of the act approved June 23, 1874, entitled "An act making appropriations for the repair, preservation and completion of certain public works on rivers and harbors, and for other purposes," for the purpose of making "a survey of the mouth of the Mississippi River, with a view to determine the best method of obtaining and maintaining a depth of water sufficient for the purposes of commerce, either by a canal from said river to the waters of the Gulf, or by deepening one or more of the natural outlets of said river." They are hereby directed to assemble at New York City, N. Y., on the 20th instant, or as soon thereafter as practicable, for the purpose of organizing and entering upon the performance of their duties.

Lieut. Col. Wright is designated as president of the Board.

H. D. Whitcomb is designated to disburse, under the direction of the Board, the money appropriated to defray the cost of the survey.

The following is the section of the act of Congress above referred to:

"SEC. 3. That a board of engineers, to be composed of three from the Army, one from the Coast Survey, and three from civil life, be appointed by the President; which said board shall make a survey of the mouth of the Mississippi River, with a view to determine the best method of obtaining and maintaining a depth of water sufficient for the purposes of commerce, either by a canal from said river to the waters of the Gulf, or by deepening one or more of the natural outlets of said river; and said Board shall make a full and detailed estimate and statement of the cost of each of said plans, and shall report the same, together with their opinion thereon, showing which of all said plans they deem preferable, giving their reasons therefor, to the Secretary

of War, to be presented at the commencement of the second session of the Forty-third Congress; and that the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any funds in the treasury not otherwise appropriated, to defray the cost of said survey."

Approved June 23, 1874.

By order of the Secretary of War:

THOMAS M. VINCENT,
Assistant Adjutant-General.

NEW YORK, *January* 18, 1875.

SIR: The Board of Engineers, constituted under section 3 of an act of Congress, approved June 23, 1874, having completed its labors, has the honor to submit the following report:

The act of Congress referred to required that the Board should make plans and estimates for the cost of obtaining and maintaining a depth of water sufficient for purposes of commerce at the mouth of the Mississippi River, either by a canal from said river to the waters of the Gulf, or by deepening one or more of the natural outlets of said river, and to report the same, together with their opinion thereon, showing which of all said plans they deem preferable.

The Board was ordered by the Secretary of War to meet on July 20, 1874, at New York City. It met on that day and commenced its duties.

As there has been no example in this country of the improvement of a large river-mouth so as to give an outlet to the sea with much deeper water than naturally exists on its bar, the Board, in its consideration of what experience has elsewhere shown to be practicable in such a case, has found its only examples in the mouths of European rivers.

There has been great difference of opinion among engineers, not only in this country, but in Europe, as to whether the best method of securing a deep-water outlet from a sediment-bearing river which empties, like the Mississippi, the Vistula, the Danube, and the Rhone, into a nearly tideless sea, is by jetties or by a lateral canal.

At the Vistula, after vain attempts for many years to improve the natural mouth, the river formed a new outlet, and the old one, turned into a lateral canal, has long given the needed water-way to the important port of Dantzic.

At the mouth of the Danube, after the canal system and the jetty system had each been proposed by eminent authorities, and neither adopted, as a final plan it was decided, in order to do something, to try feeble jetties as a provisional scheme. The results were far better than the engineer expected, and the jetties made permanent, give an admirable outlet to the Danube to-day.

At the mouth of the Rhone, the engineers, after trying for many years to secure a good outlet by dykes, which, however, never reached the bar, abandoned that plan and built a lateral canal, which is more than adequate to the wants of commerce.

While the results were so contradictory, the information at the command of the Board about the above-named foreign rivers was, except for the Danube, not recent, and very meager.

The interests involved in the proper improvement of the mouth of the

Mississippi are so great, and the work so costly, that it is imperative to obtain the best possible knowledge and judgment as to the method to be adopted. Accordingly, in order that the opinion of the Board should be based on a full knowledge of what has been done, and of the latest results obtained elsewhere, in this most difficult branch of engineering, it was decided to visit the mouths of the rivers mentioned, and, as bearing on a canal and a harbor, also the North Sea and Suez Canal.

The result of these examinations abroad (while additional information has been gained on almost every point relating to the problem before them) has been to largely strengthen their estimate of the value for jetties, at the mouth of the Mississippi River, of the fascine-dikes used in Holland by Caland in the improvement of the Maas mouth of the Rhine.

After returning from Europe, the Board met in New Orleans, spending about three weeks, of which eight days were employed in examinations at the mouths of the Mississippi River, and at the site for a canal proposed by Captain Howell.

After this history of the proceedings of the Board, the conclusions reached will be given.

I.—CANAL.

A number of locations for a canal were considered by the Board, among which may be mentioned the one proposed by Captain Howell, near Fort Saint Philip; one leaving Pass à l'Outre, about six miles inside its bar, and running north into deep water; one leaving Southwest Pass, about six miles inside of its bar, and running east into deep water; and one obtained by closing the South Pass at its head by a dam and entering it by a canal and lock from the Southwest Pass, and opening its mouth by dredging, the mouth being protected by jetties.

The advantages of the sites at Southwest Pass and Pass à l'Outre are, that the difference of water-level at the two ends of the canal will rarely exceed a foot, and may often be so small that the use of the lock-lift would be unnecessary; that the canals would be only about three miles long, and, being near navigable passes, all light-draught vessels would go through the passes; and that these canals would debouch into deep water at once, while at a distance of six miles from the Gulf outlet of the Fort Saint Philip Canal there are only 28 feet of water at low tide.

The objection to the site at the Southwest Pass is, that its *débouché* would gradually silt up in the advance of the delta, and that the cost of the harbor covering its entrance would be excessive. The same objection of excessive cost for protection of entrance applies to the site at Pass à l'Outre, while the proposed outlet of the Fort Saint Philip Canal is largely protected by Sable Island, and does not need expensive works to cover its entrance. The sites below the head of the passes do not give the same promise of permanence as that near Fort Saint Philip. The plan of canalizing the South Pass would involve the difficulty of opening and keeping open its mouth, which is the main difficulty should jetties be applied.*

* One member is of opinion that the site for a canal between the Southwest Pass and East Bay has a decided advantage over the Fort Saint Philip site.

After a careful consideration of the several sites, that in the vicinity of Fort Saint Philip was adopted, with one dissenting member. Aside from the question of cost, it offers greater hopes of permanence than the other sites. It does not seem probable that the river will ever deviate very far from its present position at the head of the proposed canal, and a comparison of the 24-foot curves at Sable Island on Talcott's map of 1838 and Captain Howell's map of 1872 show no important change. The Board decided, then, that the canal, for which plans and estimates should be made by them, should leave the Mississippi at a point about five and a half miles below Fort Saint Philip, at such an angle with the river that vessels would be able to enter it easily; that about a mile from its beginning there should be a basin of 1,000 feet by 2,500 feet; that before reaching the basin, and near it, there should be a lock, 500 feet long between its miter-sills, of 65 feet clear width, and with 27 feet of water on its miter-sills at mean low tide; the part of the lock in the vicinity of the gates to be of masonry, on a piled foundation, with heavy grillage; the rest of the prism of the lock to be of earth, with revetted slopes of one upon one; guard-gates to be placed above and below the lock; the canal to be 200 feet wide on the bottom, 27 feet deep at mean low water, and with side-slopes of ½, (or one vertical on two horizontal,) allowing these to flatten if they will, (the bank of Cubett's Gap stands on a slope of nearly one on one to a depth of 60 feet); leaving the basin, the canal to run in a straight line to the little bay behind Sable Point, beginning to widen when it reaches 6 feet of water in the Gulf, and widening to 1,400 feet at 24 feet of water; beyond the depth of 12 feet in the Gulf, the canal to be without banks. As, in spite of every precaution, accidents might occur which would make it impossible to use the lock for a considerable period of time, a second entrance from the river to the basin should be begun as soon as the canal is completed; this second entrance having its own lock and guard-gates. As there will be a tendency to silt up at the river end of the canal, and also in the cut at the other end, leading to deep water in the Gulf, some dredging will be necessary. Should that at the Gulf end prove large, it might become advisable to build dykes along the sides of the cut. The cost of the dredging and the cost of working the canal have been capitalized, and added to the first cost in the following estimate:

The first cost of the canal complete is estimated at	$10,296,500
The annual cost of maintenance is estimated at $60,885, which, capitalized at 5 per cent	1,217,700
Giving for the sum needed to build and maintain canal	$11,514,200

The canal is about six and a third miles long, passing through a country of which no part is more than 3 feet above tide, and much of its route lies through shallow lagoons. At 2 or 3 feet below the surface, the delta at and below the site of the canal is everywhere of bluish mud or clay, into which a pole can be thrust, by hand, from 5 to 15 feet. On the bars, the wave-action has sifted out and left the coarser sand in thin layers, and such strata, perhaps from the same cause, are found elsewhere in the delta.

Borings 100 feet deep show the same clay, becoming more compact, and mixed with occasional sand. At Fort Saint Philip Canal, low water of the river is 0.7 foot above the mean level of the Gulf, and high water 7 feet above the same plane. It is estimated that high water of storms at Sable Point is sometimes 7 feet above mean level of the Gulf. The lock is therefore planned for a lift of 7 feet; but as the water at Sable Point will never be higher than that of the river at the other end of the canal, except for a few hours during violent storms, no provision is made for locking down into the Mississippi. Guard-gates near the lock are provided to prevent currents rushing in either direction through the canal.

For details as to plan of canal and estimates, see Appendix A.

II.—DEEPENING NATURAL OUTLET.

The methods which have been proposed for opening a passage through a bar at one of the mouths of the Mississippi are two:

First, by stirring up in some way the material of the bar, so that the current shall sweep it away into deep water;

Second, by confining a mouth of the river by jetties on the bar, so that, aided, if necessary, by dredging or stirring up, the water shall be able to scour a channel through the bar, and to maintain it when once formed.

Judging from the results thus far obtained, the board is of the opinion that no admissible expenditure of money can permanently maintain by the stirring process a depth of 20 feet at mean low water at the mouth of the Mississippi; and as they do not consider this an adequate depth, they deem the first process named inadmissible.

In considering the method by jetties, it may be well to state the facts on which their application at the mouths of the Mississippi is based. On examining a map of the mouths of this river, it will be seen that each pass through the greater part of its length has a nearly constant width, but that it widens toward its bar, so that on its outer crest it has several times its ordinary width, while its depth is less in something like the same proportion. The cause of this change seems to be the following: The river-water as it approaches the bar is somewhat above the level of the Gulf, and so tends to diverge, the stream thus becoming thinner and wider. This thinning and widening is aided by the greater density of the salt water, which makes the fresh water rise over it on a slope that is steeper as the velocity of the river-water is less. This thinned sheet of water forms its own banks as the bar moves out to sea; but, as in this wide, shallow stream the friction is great near the banks, deposits begin there, the stream is narrowed and deepened, and in time that part of the stream obtains the form already assumed by the portion above, which allows the water to pass with least resistance. To-day, while there are but 7 feet of water on the outer crest of the South Pass bar, it is yet only about 12,000 feet from the bar to 30 feet of water above the bar, and it follows, if the bar's progress into the Gulf has been for the last one hundred and twenty years the same as for the last thirty-six years, (about 100 feet per annum,) that one hundred and twenty years ago the outer crest of the South Pass bar was where now there is a deep channel. As the bars move out to sea, the river is, then, all the time eroding a channel of the character-

istic deep-water cross-section, behind and through them. The object of jetties is to aid and hasten this erosion. If, starting from a point in a pass above its bar, where there are now 30 feet of water, we build jetties which so confine the pass that it shall have the width all the way to deep water it now has at the starting-point, we shall be helping the pass to assume the deep-water cross-section it would ultimately take, and by aiding it, if necessary, by dredging, should be able to reduce at pleasure the time required for the process.

This plan is then adopted for the improvement of a natural outlet, namely, to begin parallel dikes at the banks of a pass where there are now 30 feet of water in the middle, and carry them over the bar to 30 feet water outside (unless the depth is obtained before the dikes have reached the 30-foot curve), allowing the river to erode the bottom between the dikes till the water-way between them everywhere has the same cross-section as at their beginning, aiding the erosion by dredging or stirring if it is not rapid enough without.

The Board considered the question of limiting the water-way to the cross-section of 30 feet maximum depth, by converging jetties on the bar, and by spur-dikes in the pass above, instead of by parallel dikes. In view of the lack of experience in such work in this country, and of the danger of excessive scour around the ends of spur-dikes, it was deemed advisable to adopt parallel dikes as offering fewer contingencies and less difficulty of construction. The depth of 30 feet has been chosen, in order that some time may elapse before the bar, which will form at the sea-end of the jetties, can have less than 25 feet at mean low water upon it, that being the minimum depth which it is desired to maintain.

Having adopted a general plan for the improvement of one of the natural outlets, it remains to fix on that one. As the improvement of any will be costly, but one should be improved, and that should be made adequate for all purposes.

The passes which have been most carefully considered are the South and Southwest.

In comparing these passes, it is seen that while the average width of the body of the South Pass is 700 feet, that of Southwest Pass is about 1,400. The greater width is more favorable to navigation; but, in the opinion of the Board, the South Pass, when improved, will be adequate to the present and prospective wants of commerce. The estimated sum required for the construction and maintenance of the works for the improvement of the South Pass is $7,942,110, and for Southwest Pass is $16,053,124. It is assumed that the Southwest Pass bar advances about three times as fast as the South Pass bar.

The South Pass being entirely adequate, the much greater cost of improving the larger pass would not, in the opinion of the Board, be warranted either by the somewhat greater ease of entering it in storms, or of navigating it when once inside. The former is 12.9 miles long, the latter being 18 miles, and is lengthened only about one-third as fast as the latter.

The cost of improving Pass à Loutre would also be far greater than for South Pass, without advantages sufficient to justify the increased cost. The South Pass has the advantage that the works for its improvement, which would require at least two or three years for their execution, would in no way interfere

h commerce. The board is, therefore, of opinion that if any natural outlet improved, it should be the South Pass.

The South Pass of the Mississippi is 12.9 miles long, has an average width 730 feet, and a minimum interior channel depth of 29 feet. It is 11,900 t from the 30-foot curve inside the pass across the bar to 30 feet outside. e minimum depth on the bar is 7 feet. It discharges at its mouth about ,000 cubic feet of water per second, and about 22,000,000 cubic yards of diment in suspension per annum. It has a shoal at its head, with a minimum pth on it in channel of 17 feet.

For the improvement of the South Pass, the Board recommends parallel kes or jetties, constructed of brush, fascines, and stone, in the same general ay as those used by Mr. Caland at the mouth of the Maas.

These dikes should begin at the two banks of the pass, about 1,650 feet be- w the South Pass light-house, where the river has a width of nearly 900 feet nd a maximum depth of 30 feet. They should run in straight lines, parallel o each other, in the direction of the pass, to where the water is 30 feet deep utside of the bar, provided it should be necessary to carry them so far to ecure 30 feet depth. The dikes for the first 7,100 feet should be 10 feet wide on top; should then widen gradually to 20 feet in a further distance of 2,050 feet; should then gradually widen to 50 feet, which is to be the width in 30 feet of water. At present, this last length would be about 2,750 feet, and the total length of each dike 11,900 feet. The first 7,100 feet of the dikes to have side-slopes of $\frac{1}{3}$, (two vertical to three horizontal,) the rest to have side-slopes of $\frac{1}{4}$ down to 15 feet below water, and beneath that depth slopes of $\frac{1}{2}$. The top of the dikes to be rounded and paved, the crown rising to high-water of spring-tides.

The question of the average annual expense of prolonging the jetties is a very serious one; it depends on the annual advance of the 25-foot curve, that depth being required. At present, the muddy water issuing from the South Pass spreads out in somewhat of a fan-shape, the handle of the fan being at the mouth of the pass and the ribs several miles in length.

If the proposed jetties were instantly completed, and the new channel scoured out, essentially the same amount of sediment would be spread out in fan-shape, but, from the greater velocity of the issuing water, the ribs of the fan would be longer, while the handle would be narrower. More of the sediment would at first be deposited far out in the gulf than before.

But with the present rate of advance, the 25-foot curve one hundred and twenty years ago was about 12,000 feet above its present position; and if the volume of water carried by the pass is kept the same, neglecting the slight difference in slope of the gulf bottom outside the present bar, in about one hundred and twenty years a new end for the pass will probably be formed of the same general shape as the lower 12,000 feet of the present pass. It makes little difference, in the whole time required to accomplish the work, whether the same volume of water flows out at starting over the present shallow bar or from between two dikes which force the water to take a depth of 30 feet. In an average of many years, the rate of progress must be about the same as now, namely, 100 feet per annum, the volume of water being kept as at present; and it is on this basis that the average annual cost of extension, namely, $120,000, has been computed.

It has already been stated that it is proposed to obtain a depth of 30 feet between the jetties, in order that some years may elapse before the shoal which will form beyond the jetties can have on it less than the required depth of 25 feet in the channel through it. There are no precise data for estimating this period. Going seaward from the upper end of the proposed dikes, the slope of the bottom of the South Pass is about $\frac{1}{440}$. This slope doubtless depends mainly on the velocity of the water flowing through it, and on the lifting of the fresh water by the salt. As the causes remain essentially the same, it would seem natural that the new end of the South Pass, to be formed by the sediment passing through the jetties, should at least have the same bottom slope. If this assumption were true, the bottom would at last shoal from 30 to 25 feet in a distance of $5 \times 440 = 2{,}200$ feet, and the time required would be about 22 years. This time would be shortened by two causes. First, there are about 3,000,000 cubic yards of material to be scoured out between the jetties, thus increasing the general bar-accretion by that amount and hastening the advance of the pass. As the scour would be distributed over several years, and as the South Pass carries about 22,000,000 cubic yards of sediment in suspension annually to the Gulf, the effect of this 3,000,000 yards cannot be relatively large. Secondly, at and below the point where it is proposed to begin the jetties, the river velocity now diminishes very slowly, as it is confined by a slowly widening channel, while, when the jetties are completed and the channel scoured out, the water issuing from them will, having at first no banks to confine it, spread out more rapidly, thus, perhaps, losing velocity more rapidly and forming a steeper seaward slope on the bottom than now exists at the upper end of the proposed dikes. This steeper slope seaward from the 30 feet of water between the jetties would give a shoal of 25 feet at a distance of less than 2,200 feet, and in a period of less than 22 years. The period is unimportant; experience alone can determine the precise time. Different estimates made on this method, and others by different members of the board, vary between 10 and 30 years have been assumed for the purpose of estimate. In 10 years, then, it is assumed that the jetties will have to be lengthened 1,000 feet. As shoals will have formed at the ends of the jetties, it has also been assumed that the extension will be in water averaging 15 feet in depth.

It has been stated that there is a shoal at the head of South Pass, with but 17 feet of water on it. At present, this shoal is scouring out. Should that scouring not give a depth as great as at the shoalest point below in the pass, the construction of a dike to deflect more water into it would become necessary. Should the South Pass increase much beyond its present size, it might become necessary to put an apron on the bottom and sides of the pass, near its head, to stop that increase.

Estimates of the cost of the jetties and of the works which may be needed at the head of the pass are given in Appendix B.

First cost of jetties at mouth of South Pass, of dredging, and of works at head of pass	$5,342,110 00
Average annual cost of extension, including removal of mud-lumps, should they rise, $130,000, which, capitalized at 5 per cent., gives	2,600,000 00
Cost of construction and maintenance of improvement	$7,942,110 00

The Board also made an estimate of the cost of improving the Southwest s, the result of which is as follows:

t cost of improving Southwest Pass by jetties	$8,253,124 00
rage annual cost of extension, $390,000, which, capitalized t 5 per cent., is	7,800,000 00
n required to improve and maintain Southwest Pass	$16,053,124 00

III.—METHOD RECOMMENDED.

The Board has now given plans and estimates for improving the mouth of Mississippi either by a canal or by opening one of the natural outlets. It lso required to give its opinion as to which plan is preferable. Leaving aside for the moment, and assuming that one plan can be as easily exe- d and maintained as the other, there is no question that the improvement he South Pass would be best. It would give a good sea-entrance about feet wide, and a minimum width in the pass of about 530 feet, while the th of the canal would be about 300 feet. It would offer no locks (liable to r suffer injury) to delay the passage of vessels through it. It would give mple unobstructed water-way to commerce in place of a narrow and ob- cted one.

If the question of cost and maintenance be considered, we have for the al $11,514,200 against $7,942,110 for the South Pass.

The only remaining question is whether the two plans can be executed and ntained at about the estimated costs.

For the canal, the difficult points are to maintain a coffer-dam and secure a le foundation on which to build the masonry. By proper examinations, it elieved that sites can be found where coffer-dams can be maintained; and, ough the masses of masonry are heavier than any which have been built in region without settling, it is believed that, by the plan proposed, injuri- settling would be prevented. The Board is therefore of opinion that the al can be built at the estimated cost.

In the improvement of the South Pass, the difficult points are the control he water entering it, the removal of the shoal, and the maintenance of a nnel at its head, and the execution and maintenance of that part of the es lying outside of the outer crest of the bar. While the proper method ontrol of the water at the head of the South Pass must be learned mainly trial, great difficulty is not anticipated, as such control was readily ob- ed on the Sulina. The construction and maintenance of the jetties ond the crest of the bar is a difficult work, in which there will be contin- cies arising from the action of heavy storms, either on the jetties them- es or on the material on which they rest, and from settling. A liberal wance has been made for such contingencies, and the Board sees no reason ncrease its estimate. Indeed, it is of opinion that experience in construc- may very probably show that the cross-section of the dikes may be uced, thus lessening the cost. If the jetties are constructed and main- ed, the ends being prolonged as becomes necessary, the board has no doubt t the desired depth will be obtained.

It therefore recommends that the South Pass of the Mississippi River be improved by the plan already given.

The Board concludes its report with the recommendation that, if Congress decides to open one of the passes of the river, the entire sum necessary to accomplish the work be appropriated at once, or in some way be made available.

If the mouth of the river is to be improved by jetties, the work, when once begun, should be pushed as rapidly as possible to its entire completion.

The Board is of opinion that the works it proposes for the improvement of the South Pass can be completed in three years.

Respectfully submitted.

B. S. ALEXANDER,
Lieut. Col. of Engineers, Brt. Brig. Gen., U. S. A.
C. B. COMSTOCK,
Major of Engineers and Brt. Brig. Gen.
HENRY MITCHELL,
U. S. Coast Survey.
T. E. SICKLES.
W. MILNOR ROBERTS.
H. D. WHITCOMB.

I concur in so much of the report as refers to the selection of the South Pass for the trial of the jetty system of improvement, if that system is to be adopted; also, to the plans and estimates for both canal and jetties; but as, in my judgment, the chances of success of an attempted improvement of any one of the natural outlets of the river do not justify the recommendation of the Board, I have withheld my signature from the report.

If an adequate and permanent channel *could* be obtained at any one of the passes, it would no doubt be preferable to the proposed canal.

As the ship-canal project does, in my judgment, offer reasonable chances of success, I must give it the preference over the jetty project recommended by the Board.

H. G. WRIGHT,
Lieut. Col. of Engineers, Brt. Maj. Gen.

Hon. W. W. BELKNAP,
Secretary of War, Washington, D. C.

APPENDIX III.

(See page 65.)

THE GRANT

FROM THE

UNITED STATES,

AUTHORIZING THE CONSTRUCTION OF

THE JETTIES.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

SEC. 4. That James B. Eads, of St. Louis, Missouri, be, and he is hereby, authorized, with such others as may be associated with him, on the conditions hereinafter mentioned, to construct such permanent and sufficient jetties and such auxiliary works as are necessary to create and permanently maintain, as hereinafter set forth, a wide and deep channel between the South Pass of the Mississippi River and the Gulf of Mexico, and for that purpose he may construct, in the river, outlet or pass, and likewise in the Gulf of Mexico, such walls, jetties, dykes, levees, and other structures, and employ such boats, rafts, and appliances as he may, in the prosecution of said work, deem necessary: *Provided*, That no such structures or means employed shall hinder, delay, or materially interfere with the free navigation of said pass; and, to protect his said works, he may build and maintain such levees, or embankments as may be necessary to secure their permanency along the banks of the river or South Pass: *Provided further*, That unless the construction of the proposed work shall be substantially commenced within eight months from the date of the approval of this act, and prosecuted with due diligence, the provisions contained herein in relation to the said South Pass shall be null and void; and unless the said Eads and his associates shall secure a navigable depth of twenty feet of water through said pass within thirty months after the

date of the approval of this act, Congress may revoke the privile granted in relation to the said South Pass and cancel the obligati assumed by the United States. And Congress may revoke the herein granted in relation to the said South Pass, and cancel the o herein assumed by the United States, unless the said Eads and his shall, after securing twenty feet of water, secure an additional dep less than two feet during each succeeding year thereafter, until twen shall have been secured; and in case said Eads and his associates sh comply with the foregoing conditions, as to depth of water, and tim period of twelve months in excess of the time fixed, as aforesaid, privileges herein granted, and the obligations herein assumed in r the said South Pass, shall absolutely become null and void withc by Congress.

SEC. . That the conditions herein prescribed being fully comp the United States hereby promise and agree to pay to said Eads, or signs or legal representatives, five million two hundred and fifty thou lars for constructing said works and obtaining a depth of thirty fe channel, and the annual sum of one hundred thousand dollars for every year that said depth of thirty feet shall be maintained by the j auxiliary works aforesaid in said South Pass during twenty years aft curing the said depth. Payments shall be made on certified stateme engineer officer, who shall be detailed by the Secretary of War, a duty it shall be to report the depth of water and width of channel se maintained from time to time in said channel, together with such ot mation as the Secretary of War may direct. When a channel of t in depth, and of not less than two hundred feet in width, shall hav tained by the action of said jetties and auxiliary works, five hundred dollars shall be paid; and when a channel of twenty-two feet in d two hundred feet in width shall have been obtained by the action of s and auxiliary works, five hundred thousand dollars shall be paid. channel twenty-four feet in depth and not less than two hundred and in width, shall have been obtained, there shall be paid five hundred dollars; and after said depth and width shall have been maintain twelve consecutive months, there shall be paid two hundred and fifty dollars, with five per centum per annum interest from the date v twenty-four feet were first obtained. When a channel twenty-s depth, and not less than three hundred feet in width shall be obtai shall be paid five hundred thousand dollars; and when a channe depth and width shall have been maintained for twelve months tively, two hundred and fifty thousand dollars shall be paid, with five per centum per annum from the date when said channel wa tained.

When a channel twenty-eight feet in depth, and not less t hundred and fifty feet in width shall be obtained, there shall be hundred thousand dollars; and after said depth and width shall l maintained for twelve months consecutively, two hundred and fifty dollars shall be paid, with interest at six per centum per annum fron when said twenty-eight feet were first obtained. When a channel t in depth and not less than three hundred and fifty feet in width sh

ained, there shall be paid five hundred thousand dollars; and after said depth nd width shall have been maintained for twelve months consecutively, there hall be paid five hundred thousand dollars with interest at five per centum er annum from the date when a channel of said depth and width was first obained; making a total aggregate of four million two hundred and fifty thouand dollars for the aforesaid payments, the respective depths and widths of channel being measured at average flood tide, as ascertained and determined by the Secretary of War. When a channel thirty feet in depth, and three hundred and fifty feet in width, shall have been obtained by the effect of said jetties and auxiliary works aforesaid, the remaining one million dollars shall be deemed as having been earned by said Eads and associates; but said amount shall remain as security in the possession of the United States for the purpose hereinafter set forth, interest at five per centum per annum on the same being payable to said Eads, his assigns, and legal representatives, semi-annually, from the date when a channel of thirty feet in depth and three hundred and fifty feet in width shall have been first secured, so long as said money, or any part thereof, is held by the United States.

SEC. . That after said channel of thirty feet in depth and of not less than three hundred and fifty feet in width shall have been secured, one hundred thousand dollars per annum shall be paid in equal quarterly payments during each and every year that said channel of thirty feet in depth and three hundred and fifty feet in width shall have been maintained by said Eads and his associates by the effect of said jetties and auxiliary works aforesaid in said pass, for a period of twenty years, dating from the date on which said channel of thirty feet in depth and three hundred and fifty feet in width shall be first secured: *Provided, however*, that no part of such annual compensation shall be paid for any period of time during which the channel of said pass shall be less than thirty feet in depth and three hundred and fifty feet in width, as hereinbefore specified.

SEC. . That the said channel of thirty feet in depth and three hundred and fifty feet in width having been maintained for ten years, one-half of the one million dollars hereinbefore mentioned shall be released and paid to said Eads, his assigns, or legal representatives; and said depth and width having been maintained for ten additional years, the remaining half of said one million dollars shall be released and paid as aforesaid. And if any of said money shall have been paid under the provisions of this Act as hereinafter provided, then the residue shall be paid at the times above stated.

SEC. . That in case said Eads and associates, in order to maintain a channel of thirty feet in depth and three hundred and fifty feetin width, shall deem it necessary to expend on such work, during any one or more of said twenty years, any money in excess of the annual payments received by them during said year or years under this Act, the Secretary of War shall, on satisfactory proof of such expenditures, authorize, as often as such extra expenditures may require, the payment of the same from the said money in pledge, to said Eads or his legal representatives. And such payments shall be made from the five hundred thousand dollars to be released at the end of ten years before any payment shall be made from the five hundred thousand dollars to be released at the end of twenty years; and if any failure to maintain said channel of thirty feet in depth and three hundred and fifty feet in width shall occur, the date

for releasing the said money held in pledge shall be postponed for an equal period of time, and the compensation for maintaining said channel shall cease until said depth and width shall be again restored, the maintenance of a channel thirty feet in depth and three hundred feet in width for twenty years, exclusive of all such periods of failure, being intended by this act. And at any time after said jetties shall have been completed, and said channel of thirty feet in depth and three hundred and fifty feet in width shall have been obtained, that the United States may elect to pay the said one million dollars, and stop the payment of said interest and said annual sum of one hundred thousand dollars for the maintenance of said depth and width, said United States shall have the right to do so on payment of said money held as security and in pledge as aforesaid, together with the interest and annual compensation for maintenance which may be earned at the date of such final payment; and on such payment being made by the United States, the supervision and maintenance of said jetties and auxiliary works by said Eads and associates, and all liability on their part, shall cease and determine.

SEC. . That in order to facilitate the proper location of said jetties, which shall not be less than seven hundred feet apart, and to correctly determine such effects as may be produced by them, the Chief of the Coast Survey shall, as soon as practicable, cause a careful topographic and hydrographic survey to be made of said pass and bar, and shall submit the same to the Secretary of War, who shall furnish to said Eads the results of any such survey. And the sum of five thousand dollars is hereby appropriated out of any money in the Treasury not otherwise appropriated for said survey and examination.

SEC. . That any person maliciously or intentionally injuring said works, or interfering with the construction thereof, shall be deemed guilty of a misdemeanor, and may be tried for such offense before the District Court of the United States for the district wherein such offense may be committed; and, if found guilty, he shall be liable to a fine not exceeding one thousand dollars, or to imprisonment for not more than two years, or to both fine and imprisonment as aforesaid, for each offense.

SEC. . That the said Eads and his associates shall have the right under such regulations as the Secretary of War shall prescribe, to use any materials on the public lands of the United States that shall be suitable for, and may be needed in, the construction of said works.

SEC. . That in case of death or other disability of said Eads before the completion of said works, the same shall be prosecuted and completed by his legal representatives and his associates aforesaid, with the same powers, rights, obligations and compensations as if done by him in person.

SEC. . That the Secretary of War be, and is hereby, authorized and directed to carry into effect the provisions of this Act on behalf of the United States, and, when the said Eads and his associates shall, from time to time have fulfilled on their part the several foregoing conditions of this Act, t draw his warrants upon the Treasurer of the United States in favor of sai Eads, or his legal representatives, in payment of the aforesaid amounts as the respectively become due by the provisions of this Act. And it shall be the dut of the Secretary of War to embody in his annual reports the payments mad from time to time under this Act, and the probable times when other paymen

ll become due, and to report during the construction of the work herein thorized all important facts relating to the progress of the same, the mate-ls used, and the character and permanency with which the said jetties and xiliary works are being constructed, to the end that the Congress of the ıited States may be kept fully advised as to the faithfulness and efficiency th which the said works are being executed by the said Eads and his associ-es, it being expressly understood that while said Eads shall be untrammeled the exercise of his judgment and skill in the location, design and construc-on of said jetties and auxiliary works, the intent of this Act is not simply to cure the wide and deep channel first above named, but likewise to provide r the construction of thoroughly substantial and permanent works by which id channel may be maintained for all time after their completion. And in se the Secretary of War shall be of the opinion that this work is not being nstructed according to the spirit and intent of this Act, he shall report the me to the President, who shall appoint a commission, consisting of an officer the Army, an officer of the Navy, and a competent person from civil life, inspect and examine the works being constructed by said Eads and his as-ciates; and in case the said commission shall report that the works are being nstructed upon a design that will not be of a substantial and permanent aracter when completed, all the facts in the case shall be laid before Con-ress at the earliest possible moment, and payments upon said works shall be spended until Congress shall otherwise order.

SEC. . That the option of discharging the obligations herein assumed by ıe United States, either in money or bonds, is expressly reserved; and the ecretary of the Treasury is hereby directed to issue the bonds of the United tates, bearing five per centum interest, of the character and description set ıt in the act entitled "An Act to authorize the refunding of the public debt," pproved July fourteenth, eighteen hundred and seventy, to said Eads or his gal representatives, in payment at par of the aforesaid warrants of the Sec-tary of War, unless the Congress of the United States shall have previously rovided for the payment of the same by the necessary appropriations of ıoney: *Provided*, That in no case shall the Government of the United States be able for any losses incurred by said Eads and his associates in the perform-nce of the work herein mentioned, nor shall any payments thereon be made ı excess of the sums nor contrary to the terms hereinbefore prescribed.

Approved March 3, 1875.

APPENDIX IV.

(See page 92.)

PROCEEDINGS

OF THE

ADVISORY COMMISSION OF ENGINEERS

CONVENED BY

JAMES B. EADS,

TO CONSIDER HIS PLAN FOR THE IMPROVEMENT OF THE

MOUTH OF THE MISSISSIPPI RIVER.

Minutes of the Proceedings of the Board:

NEW YORK, September 2, 1875.

"The first point considered was the proper line for the eastward jetty, and after examination and discussion it was recommended by the Board to fix the line as follows, viz.: Begin about 6,380 feet from the Land's End, and about 1,080 feet beyond the mattress laid September 1st, and in the line submitted by Mr. Eads; thence curve southward, on a radius of 20,000 feet, to the 30-foot contour line without the bar. Total curvature, 17° 30', and course of tangent at proposed end of jetty, S. 27½° E., approximately."

September 3, 1875.

The Board then proceeded to discu the proper width between the jetties at their outer ends, and recommended that it remain as proposed by Mr. Eads—at 1,000 feet at water surface at ordinary high tide. A discussion as to the proper line of the west jetty then followed, and pending the discussion, the Board adjourned."

September 4, 1875.

"The line of the eastern jetty was reconsidered. Mr. Eads stated that the piling on the line of the east jetty had already been driven to within 2,400 feet of the jetty head, and a change in the radius of the curve to 20,000 feet, as recommended by the Board on the 2d inst., would involve considerable additional expense and some delay. He proposed a curve with a radius of 16,000 feet, beginning in the straight line at or near station 72+70 feet, curving southward, and passing through a point in the line of the jetty submitted to the Board, 11,700 feet from the signal station. The Board concurred with Mr. Eads in his views, and modified the recommendation of September 2 accordingly.

"The consideration of the line of western jetty was then resumed.

"The Board having decided that 1,000 feet is an advisable width between the jetty heads, and having fixed the alignment of the east jetty, is unanimously of opinion that a strictly parallel alignment for the western jetty is in accordance with the theory of jetty action; that departures from such alignment would be advisable, if at all, only on the grounds of economy, facility, and rapidity of construction; they concur in the alignment proposed by Mr. Eads, and leave that matter to his discrimination, aided by the experience gained on the spot; and as regards the length of the western jetty, the Board think it advisable that the eastern, being the windward jetty, should overlap the western by at least 300 feet."

September 6, 1875.

"After an examination of the map, showing the changes of depth which have occurred in the South Pass since the works were begun, a discussion followed as to the proper point for terminating the east pier, and also as to the construction of the jetties. As two members of the Board were absent, the Board adjourned at 4 P.M., these subjects being still under consideration."

September 7, 1875.

"The Board resumed the consideration of the construction of the jetties, and adopted the following recommendations, viz.:

"That with regard to priority of construction, the Board recommends that the seats of both jetties, and of the spur joining the west jetty with the right bank, be protected throughout their entire length, and that then the foundations of the east jetty be carried up to the water-line before raising the mattress-work of the west jetty to the same level.* The construction details of the pier head to be left undetermined until the Commission can meet at the jetties in November.

"The Board then adopted the following:

"After an attentive examination of the plan of construction, consisting of a combination of willow mattresses and stone, now in execution by Mr. Eads, the Board find it a modification of methods long in use in Holland and else-

*Sir Charles A. Hartley is of opinion that the east jetty should be brought up to the water-line (to its full height), as far as a depth of at least 20 feet, before raising the mattress-work of the west jetty to the same line.

where. It is essentially the same as that applied to the jetties at the mouth of the Oder, and also to the jetties at the mouth of the Maas, so successfully as to draw from the lower legislative body of Holland the announcement that 'their complete success has removed all doubts as to the possibility of making piers at sea on our coast.' It is, moreover, essentially the same as that adopted by the recent Commission for these works.

"The Board farther advise that Bayou Grande be left open for the present.

"The consideration of works necessary at the head of the pass was then begun; pending this, the Board took recess, to meet at 8 P.M."

September 7, 8 P.M.

"After a very thorough consideration of different projects, the Board recommended unanimously the construction of one jetty immediately; starting on a tangent to the east bank of entrance to the pass, *i.e.*, to a meridian line nearly, and curving then to the westward on a radius of 8,000 feet, till it reaches the 24-feet contour line. The further prolongation of this work, and the execution of works on the west side, to be left for determination after observation of effects produced by the construction recommended."

September 8, 1875.

"The minutes of the Board from the first were read and approved, and the Board adjourned to meet at New Orleans November 10, 1875."

Copied from the Minutes.

(Signed) R. S. ELLIOTT.

FINAL PROCEEDINGS OF THE COMMISSION.

PORT EADS, LA., *Nov.* 18, 1875.

The commissioners, Gen. J. G. Barnard, Sir Charles A. Hartley, W. Milnor Roberts, Prof. Henry Mitchell, and H. D. Whitcomb, assembled in New Orleans, November 15th, and proceeded to Port Eads on the 17th. After visiting the works in progress, the Commission held a meeting at Port Eads on the 18th.

Present, Gen. J. G. Barnard, President, and Sir Charles A. Hartley, W. Milnor Roberts, Prof. Henry Mitchell and H. D. Whitcomb.

Communications were received from General Alexander and Mr. Sickles, stating that pressing engagements prevented their attending the meeting.

The President read the minutes of the meeting of the commissioners in New York in September.

After some discussion, it was recommended by the Board that the space of six hundred feet between the north end of the west jetty and the shore, across which piles are now driven and mattresses being laid, should not be closed

il the east jetty shall have been raised to its full height out to twenty feet pth of water.

Mr. Eads having intimated to the Board that it is of importance to himself d his associates that a depth of twenty feet should be obtained at the mouth the South Pass as soon as possible, the Board recommend, in consideration Mr. Eads's representation, that provisional jetty heads one hundred feet in ngth be established in a depth of twenty feet in the line of both jetties, and at the construction of these works be in conformity with the cross section of jetty presented by Mr. Eads.

This drawing indicates:

1. That the said jetty heads shall consist of stone and fascine work, having a idth of twenty-six feet at the water line, with a slope of three to one on both des to a depth of sixteen feet.

2. That below this depth the base of the work shall have a width of two hunred and twenty-two feet, and including revetment of stone, be four feet ick, thus giving an apron fifty feet wide at the foot of each slope.

3. That the apron and slopes shall have a revetment of stone at least two et thick; and

4. That the work be crowned with paving stones, weighing not less than ne ton each, carried up to a height four feet above mean low water.

The Board further recommend that the exposed sea ends of the temporary tty heads should have the same inclination as the side slopes, it being underood that the bottom out to the depth of thirty feet in the proposed line of the st jetty is already covered with at least one layer of mattresses.

With reference to the permanent jetty heads, the Board is of the opinion at their construction, as regards profile, fascines, stones, and piles, should be arly as possible identical with that of the jetty heads at the new mouth of e Maas, where the stones employed in exposed positions averaged one hunred and twenty pounds each, and where each cubic yard of mattress work as charged with half a ton of stone. The Board also considers that a like vering of stone on the mattress should be employed in constructing the jetes at the South Pass, wherever they are liable to be attacked by heavy seas.

The Board then adjourned.

PORT EADS, *Nov.* 19, 1875.

The Board met at 9 P.M. Present, same commissioners as on the 18th. resent also, Mr. Eads. After conversation and discussion, the Board adurned without action to 9 A.M. the 20th.

PORT EADS, *Nov.* 20, 1875.

The Board met according to adjournment. Present, the same members as on last evening.

The following letter was submitted to the Board, and read, and ordered to be spread on the minutes. The personal examinations on the work made by the Board confirm the correctness of Mr. Corthell's statement:

"PORT EADS, *Nov.* 19, 1875.

"MR. G. W. R. BAYLEY, *Resident Engineer:*

"DEAR SIR:—The following is a statement of work at this date:

"There have been driven as guide piles for mattresses about 2,500 piles, extending on the east jetty to a point about 12,100 feet from East Point signal, and about 11,500 from same point on west jetty—measured on jetty lines.

The length of foundation mattresses laid in east jetty is	11,560 feet.
The length of second tier mattresses laid in east jetty is	2,850 "
The length of foundation mattresses laid in west jetty is	8,200 "
The length of foundation mattresses laid in cross dike is	600 "
Total linear feet	23,210* "

"In which there are seventy-five thousand cubic yards of material all firmly secured in its position by stone ballast. Sheet piling in the east jetty has been driven a length of three thousand six hundred feet.

"There have been constructed eight hundred lineal feet of launching ways for mattresses. Houses and boats for the accommodation of three hundred and fifty men have been placed on the west side of the pass, and on the east side a large house for headquarters' residence has been built, and all the shops, walks, and wharves necessary for works. The plant in the work consists of two floating pile-drivers, three sheet pile-drivers, five derricks, eight model barges, eight flats, two stern-wheel steamboats, two tugs, three steam launches, with yawls and other small boats.

"At the head of the passes about two hundred piles have been driven on the line of the deflecting dike, and at the Jump two hundred lineal feet of mattress ways have been constructed, with accommodations in each place for all the men required for the work.

"I am sir, yours truly,

"E. L. CORTHELL,
"*Chief Assistant Engineer.*

"Respectfully submitted to the Chief Engineer.

"G. W. R. BAYLEY,
"*Resident Engineer.*"

Whilst the Board appreciates the preparations made for carrying on the works with vigor, it is unanimously of opinion that a rapid delivery of stone on the works is essential to obtain a speedy depth on the bar, and for the protection of the jetties where they are exposed to the violence of the waves. It therefore directs Mr. Eads's special attention to this subject, with the suggestion that a deposit of at least 10,000 cubic yards of stone be piled on the river banks, near the mouth, as a reserve deposit to meet emergencies during the construction of the jetties in deep water.

November 20, 1875.

The Commission adopted the following general report, and ordered it to be entered into the minutes of its proceedings.

After having devoted three days to examining the works in progress and in

* NOTE.—Equal to a length of four miles, fifty feet wide and two feet thick.

conference with Mr. Eads and his engineers, the Commission presents the following general summary of its views:

Upon personal examination of the locality and observation of the work which has been performed, the South Pass of the Mississippi is found by the Commission to more than fulfill the expectation of its members in regard to its fitness for furnishing an open mouth of ample depth for the largest class of sea-going vessels to the Mississippi River by means of jetties.

In making this statement, reference must be had to the fact that two of the members have never before examined the locality with a view to this particular question, one indeed having never before visited the spot. Of course, on all points concerning difficulties of execution of the works recommended, they had had no actual local experimental results, while, on the other hand, opinions were rife among many that the local peculiarities of the soil, such as its extreme softness, its eruptive "mud-lumps," etc., would effectually thwart efforts to lay upon it substantial and permanent engineering constructions.

The members of the Commission had, indeed, satisfied themselves, that such opinions were unfounded; but it is satisfactory to be able to state positively, after four months of actual operations, that the work of pile-driving, extending from the east land's end to twenty-six feet depth beyond the bar crest, along a line two and a quarter miles in length, covering nearly the whole length of the eastern jetty, and an examination of the texture of the bar and of the shoals on which the works are to rest, furnish the most satisfactory evidence of a bottom material not only adequate to bear all the necessary works, but even to suggest that but for motives of economy (quarries being far distant) the jetties, as at the Sulina mouth of the Danube, might be made wholly of stone. The Commission therefore unhesitatingly announces that the supposed or attributed engineering difficulties of construction of engineering works at the South Pass of the Mississippi, as depending on peculiarities of the Mississippi delta, are illusory.

In fact, the execution of the works is far less difficult than that of several recent successful works of the kind on European shores, known to and examined by the members of the Commission. This facility of execution arises, in a measure, from the fact that the broad, lateral shoals, almost bare at low water, which extend seaward from the land's ends, marginal to the channel, form very good protection to the proposed works, and almost reduce them to the grade of mere river works until the outer edge of the bar is reached. The deep water portions, outside the bar of the proposed jetties, are comparatively short. While these portions must have the dimensions and strength of exposed sea works, they offer no difficulty not common to other similarly exposed works now existing.

It would seem proper in this connection to say a few words as to the South Pass itself, in reference to its capabilities to furnish an open mouth to the main stream, and thus form an adequate connection between the sea and the thirty thousand miles of inland navigation which ramify from the river.

The South Pass is the middle one of three great passes into which the river, after having for many hundred miles rolled in a single channel, divides a few miles before it finally discharges its waters into the Gulf of Mexico.

It is but twelve miles long, being the shortest of the passes. From its point of division it carries its waters in a channel everywhere five fathoms

or more in depth, with a straightness of course and a uniformity of section and depth such as almost to suggest to the voyager that he is navigating a canal of unparalleled dimensions, of a width averaging seven hundred feet, sufficient for the convenient transit of the largest sea-going ships, and of the congeries of vessels which constitute a tow for the powerful tug-boats in use. No sharp bend, no shoal, no reef, embarrasses its navigation.

At the origin—the head of the passes—a shoal indeed lies in advance of its entrance. This shoal has, however, a natural depth equal to that over the bar at Southwest Pass, and the Commission anticipates no serious difficulty in effecting over it the required depth. From this point the adequacy of depth continues unbroken for ten miles, till the seaward extremities of the land margins (the natural jetties which thus far maintain it) are reached. Here, released from confinement, the current diffuses itself; the depth diminishes until at two miles further (about) the bar, having but seven feet depth, is reached; beyond which, seaward, depths of six, twelve, twenty-four and more fathoms are found in quick succession. The specific engineering work which the government of the United States has committed to Mr. Eads is by the well-known method of jetties, or otherwise called parallel piers, to supply artificially throughout this two miles from the land's ends to the outer slope of the bar the confining barriers which shall prolong to the sea the uniformity of section and depth which the natural barriers for the preceding ten miles have secured.

This is not the place to discuss the abstract merits of a well-known method which has elsewhere, in reference to its application here, been thoroughly discussed and disposed of, and in which the individual members of the Commission have had each one his own part to take. What has been said in former paragraphs suffices to exhibit the strengthened confidence with which personal examination of the spot and of the works now in progress has imbued the members of the Commission.

The Commission considers the present an opportune moment to record its opinion—first, that the physical characteristics of the delta and bars of the Mississippi and Danube are similar in many important respects; and secondly, that owing to the greater sea depth immediately beyond the crest of its bar, to the existence of tide-water, to the apparent greater abrading forces along the coast, and to the extreme fineness of the sand of which the bar is composed, the mouth of the South Pass of the Mississippi is *more* susceptible of successful improvement, notwithstanding the greater turbidity of its fluvial current, than was the Sulina mouth of the Danube when, in 1858, the construction of parallel piers was commenced which secured to the navigation of that river a depth of 17½ feet in 1861, and 20½ feet at the present time, or five feet more than the works were originally designed to obtain; and this at the mouth of a river-arm discharging less than one-third of the volume of water discharged by the South Pass.

We now turn to the works actually at this time executed by the grantee, Mr. Jas. B. Eads, under the act of Congress authorizing him to improve the South Pass of the Mississippi River, and we find that they have been laid out and thus far carried on substantially in accordance with the plans submitted to and approved by this Commission at the time of their session in September last.

Considering that only the short period of five months has elapsed since the

inning of operations at the South Pass, we are struck with the amount of rk which has been accomplished ; and although much that has been done is visional, to be supplemented by other work, it is all necessary and conduc to the end in view, which is permanently to confine the flow within the ce of one thousand feet between the crests of the jetties.

We find from the records of the pile-driving, and from the manner in ich the piles have thus far withstood the action of the waves and currents, at the material of the bar is even more solid than we had ventured to anticite it would be, as we have already remarked. We do not entertain any ubt as to the efficiency and permanency of the jetties, when they shall have en completed upon the location and plans heretofore approved by this Comssion. If the arrangements made by the contractors, Messrs. James Anews & Co., for the early delivery of additional large quantities of stone for ighting the mattresses, and for the protection of the jetties against the action the sea, are successfully executed, we see no reason for doubting the realizan of definite and permanent good results at an early date.

It is hardly within our province, if it were even in our power, to offer any ecific opinion respecting the period when a given depth across the bar may reliably calculated upon, since so much necessarily depends upon the charter of the season, the stage of water in the river, and the vigor with which e works are prosecuted ; but judging from the amount and character of the rk already accomplished in advance of the date at which Congress required to begin, we are very favorably impressed, believing that there is a prospect early and complete success.

The lines of the jetties are now distinctly marked out by the rows of piles tending seaward on the east side beyond the crest of the bar into twenty-six et of water, and on the west side to about twenty feet depth, indicating the tent and shape of the new entrance.

While it would have been unreasonable to have anticipated at this early riod in the progress of this important undertaking, even as much as has ready been effected, we desire to be careful lest we should ourselves underlue or cause others to view lightly the difficulties which yet remain to be rcome before the final grand result shall have been attained.

Care should be exercised to strengthen the works already commenced, in der to enable them to resist the gales of winter ; and too much haste to call the river forces for the execution of deepening must be avoided. It is uch safer, while the foundations of the jetties are insufficiently protected by one, to allow the present escape of water by lateral avenues.

From what has already been said, it will have been clearly enough seen at the Commission did not expect at this early stage in the progress of the ork that much scouring effects would have been produced. Such results nnot be expected to exhibit themselves in a very marked manner until, by e closure of the opening (six hundred feet in length) at the head of the west tty, and by the raising of both the parallel piers to the water surface throughit some considerable length, the water shall be confined to its destined chanel. From the eastern land's end to near the head of the west jetty, the eastn jetty is now for the most part thus raised, while the west bank itself imperctly fulfills the function of its parallel pier. Throughout this length—say r four thousand four hundred feet—a marked scouring effect has taken place.

At this season of the year, when the river is low, the scouring action of the current is reduced to its minimum. This, while it is the least favorable to the exhibition of results from the jetty works thus far executed, is the most favorable to their safe and rapid construction. It is quite undesirable that any considerable deepening of the bar should occur before the spring shall find the works in a condition to resist and turn to useful account the flood that may then be expected.

On motion,

Resolved, That a copy of the minutes and of the foregoing résumé be furnished to Mr. Eads by the Secretary.

Whereupon the Commission adjourned *sine die*.

J. G. BARNARD, *President.*
CHARLES A. HARTLEY,
B. S. ALEXANDER,
W. MILNOR ROBERTS,
HENRY MITCHELL,
T. E. SICKLES,
H. D. WHITCOMB.

A true copy from the minutes.

H. D. WHITCOMB, *Secretary.*

APPENDIX V.

(See page 91.)

ESTIMATE OF THE DETAILED COST OF ONE CORD OF MATTRESS-WORK.

BASIS OF CALCULATION IS 53,415 CORDS, CONSTRUCTED AND PLACED ON THE JETTIES AND AUXILIARY WORKS. FROM JUNE 30, 1875, TO JUNE 30, 1876.

Kinds of Work or Material.	Total Quantity.	Detailed Cost.	Am't to One Cord.	Cost p'r Cord.	Total Cost p'r Cord.
Mattress Ways	1,800 lin. ft.	$3.59 pr. lin. ft.		$0.087	$0.087
Guide Piling	2,663 piles. 90,666 lin. ft.	.21$\frac{3}{10}$ pr. lin. ft.	1$\frac{7}{10}$ lin. ft.	0.360	0.360
Materials.					
Willows	53,415 cords.			1.480	
Strips	2,400M ft. B. M.	14.00 per M.	45 ft. B. M.	0.630	
Pins	214,000	.02$\frac{1}{2}$	4	0.080	
Wedges	428,000	.00$\frac{1}{10}$	10	0.010	
Cut Spikes, 5-in	26,707 lbs.	.03$\frac{1}{10}$ per lb.	0.5 lbs.	0.016	
Nails, 20*d*	23,324 lbs.	.03 per lb.	$\frac{1}{2}\frac{0}{0}$ lbs.	0.015	
Rope	74,900 lin. ft.	.06$\frac{1}{10}$ per lin. ft.	1.4 lin. ft.	0.092	2.323
Transportation.					
Barges (cost, repairs, pumping)				0.340	
Transporting				0.355	0.695
Constr'n Mattresses				0.800	0.800
Towing and Placing				0.338	0.338
Stone.					
Delivered	18,500 cu. yds	3.31 cubic yd.	0.35 cub. yd	1.158	
Handling		.06 cubic yd.		0.021	
Barges and Flats		.43 cubic yd.		0.150	
Towing		.65 cubic yd.		0.227	1.556
Sinking Matts					0.171
Total					$6.330

Waste and Incidentals, 10 per cent	0.633
General Construction Account, 15 per cent	1.044
Cost per cord of Mattress Work	$8.007
Cost per cubic yard Mattress Work	$1.687
Cost per cubic yard to Mr. Eads	8.972

(See pages 94 and 212.)

DEPTHS (COMPARATIVE) IN LINE OF DEEPEST WATER IN CHANNEL, IN FEET AND TENTHS.

Distances from East Point.	May 1875	Dec. 1875	Jan. 1876	Feb. 1876	Mar. 1876	Apl. 1876	May 1876	June 1876	July 1876	Aug. 1876	Sept. 1876	Oct. 1876	Dec. 1876	Mar. 1877	Apl. 1877	June 1877	July 1877	Sept. 1877	Dec. 1877	Feb. 1878	Apl. 1878	May 1878	July 1878	Dec. 1878	Mar. 1879	July 1879	Dec. 1879	Jan. 1880
East Point.	31.8	37.0	37.0	38.0	38.7	38.0	37.5	37.1	37.1		33.7	33.6	30.0	32.6	31.8		35.4	39.7		37.5	37.8	35.0	38.9	32.7	37.6	36.3	33.9	33.9
1,000 feet.	21.0	28.3	27.0	28.0	28.0	28.0	28.5	28.7	29.0		28.8	29.0	27.0	28.4	29.9		31.3	32.0		30.5	32.4	33.0	31.9	30.4	31.0	30.5	32.3	33.0
2,000 "	21.8	22.8	23.0	23.0	23.2	25.0	23.9	24.0	25.0		24.2	25.5	24.5	25.6	24.4		26.3	26.2		25.4	28.3	26.0	30.0	31.9	30.1	30.5	32.1	33.5
3,000 "	18.8	22.5	22.0	21.8	21.2	22.3	21.4	21.9	21.6		23.0	24.9	22.1	25.1	25.1		25.8	25.2		26.2	26.8	33.0	33.0	34.7	40.6	40.6	38.6	36.5
3,500 "	18.0	20.0	20.0	20.0	20.2	21.8	21.4	21.9	21.1		22.8	23.0	20.9	24.3	24.2		25.2	25.7	25.3	27.3	28.7	29.0	30.7	30.5	32.4	40.3	42.7	41.5
4,000 "	18.0	22.3	22.4	22.5	27.4	26.8	37.9	38.5	39.5		39.7	34.9	34.3	33.5	32.5		27.2	28.3	29.3	31.8	34.7	36.0	37.6	35.7	49.9	47.7	35.3	41.8
4,500 "	18.0	23.3	22.9	23.5	22.9	24.3	21.5	23.3	30.3		26.9	25.0	27.5	24.5	29.4		26.4	26.2	23.6	26.0	91.1	104.5	100.2	70.3	80.6	84.2	75.4	74.3
5,000 "	17.9	23.0	21.4	23.5	25.4	27.1	28.0	28.2	30.3		26.3	29.9	26.8	32.0	27.7		29.5	25.0	20.8	29.3	29.2	89.7	85.5	61.3	75.0	82.2	69.3	76.3
5,500 "	16.0	19.8	21.1	23.3	24.9	25.1	27.0	25.5	26.8		28.0	27.9	25.2	31.5			25.6	27.5	26.1	65.4	67.3	64.0	69.5	55.8	58.5	68.7	61.3	50.8
6,000 "	14.3	18.8	22.2	22.6	25.4	26.4	30.6	29.1	27.3		28.5	27.3	25.2	27.5			26.8	26.3	26.3	47.0	53.3	48.	50.5	44.8	64.5	60.2	61.3	61.3
6,500 "	14.0	16.2	18.1	17.2	23.2	24.2	28.1	30.1	26.8		29.3	28.8	24.7	25.2		24.3	25.0	29.3	27.8	39.2	39.	40	51.0	51.3	55.5	56.2	45.7	45.0
7,000 "	13.0	15.6	20.1	24.5	23.4	24.0	24.4	26.0	26.0		25.9	26.1	22.0	23.6		24.7	25.5	25.8	25.5	25.7	27.0	27.	31.3		33.0	49.7	47.8	47.0
7,484 "	11.8	13.5	14.6	24.0	22.5	21.8	24.7	27.4	24.9		25.9	26.7	22.3	23.8		27.5	30.0	31.2	26.8	26.7	28.	30.	30.1	27.3	28.0	30.5	32.8	35.3
8,000 "	11.0	13.0	14.1	18.0	18.0	22.4	26.9	28.3	26.4		26.6	27.1	22.7	23.5		31.6	32.1	30.0	26.8	29.7	31.0	32.	32.7	27.3	44.0	36.2	33.0	39.0
8,200 "	11.0	13.0	14.5	18.0	18.2	28.0	32.4	30.3	28.9		35.1	32.4	25.7	29.8		29.8	30.2	30.5	26.8	32.7	34.	33.0	34.7	29.5	34.0	36.0	34.9	40.0
8,500 "	10.9	13.3	13.1	15.0	20.4	23.2	25.8	27.6	23.9		27.9	26.5	23.7	23.6		28.7	26.0	26.7	25.3	26.7	27.	26.	28.1	28.2	29.0	32.2	32.9	44.0
9,000 "	10.5	11.8	13.0	15.0	18.0	23.2	26.9	26.8	25.6		26.8	26.9	25.8	26.9		26.6	30.2	31.0	27.0	29.0	30.9	30.0	30.1	26.4	37.5	37.2	33.8	38.9
9,500 "	10.8	10.8	11.0	13.0	17.4	20.3	27.3	25.0	26.8		30.9	31.1	29.7	28.1		29.6	29.0	28.6	30.0	27.9	33.	31.5	31.0	27.7	30.1	30.5	32.2	36.3
9,900 "	10.0	11.0	12.6	14.0	16.0	22.8	23.9	24.0	22.8		26.3	27.0	27.0	29.1		23.0	23.9	26.1	25.3	26.9	31.9	35.5	30.0	27.7	30.4	30.5	32.9	35.8
10,500 "	9.5	9.3	12.0	16.6	18.7	19.8	22.7	23.0	20.8		22.1	29.7	25.1	26.8			25.0	28.2	26.0	26.0	31.3	33.5	34.0	29.4	35.4	33.2	31.6	31.6
11,000 "	9.2	9.8	12.0	14.6	18.0	19.2	24.5	26.2	26.3		27.0	26.5	21.9	24.2		24.3	31.9	27.2	25.1	24.7	28.3	28.	28.5	27.2	27.3	31.0	31.5	31.7
11,500 "	9.2	11.3	12.0	15.0	15.9	18.2	22.7	21.5	20.8	23.5	23.3	24.2	21.6	26.0		23.3	25.0	25.0	23.4	24.2	28.1	26.1	29.5	28.0	28.8	31.2	32.4	34.7
11,700 "	9.2	16.8	17.0	18.0	15.0	17.0	18.0	21.0	22.4	23.7	22.3	23.0	21.8	24.6		21.8	25.3	23.0	24.6	24.2	27.0	29.4	29.8	26.3	28.1	30.5	32.9	34.7
11,900 "	11.8	15.0	18.0	18.5	19.0	18.0	16.5	18.3	22.8	22.5	25.3	24.0	24.5	23.0		20.1	25.7	26.0	29.0	25.2	30.0	34.0	31.4	32.5	31.9	30.5	35.0	37.1
12,000 "	30.8	30.8	34.2	33.2	30.8	31.0	30.2	30.5	30.0	23.0	26.1	25.3		21.0		21.2	32.0	29.1	35.0	35.2	40.2	40.0	40.0	34.0	41.0	42.5	41.0	41.3
12,400 "	31.0	30.0	35.0	30.0	47.0	42.0	25.0	30.0	22.8	21.0	14.0	13.4		20.4		23.3	44.0	45.	45.	45.	48.	45.	44.4					
12,800 "	35.0	...	...						41.8	39.5	44.1	43.1		39.4														

APPENDIX VII.

(See pages 94 and 212.)

INTERRUPTION OF CONTOURS.

RECORD OF DISTANCES IN FEET THROUGH THE BAR BETWEEN THE CONTOUR LINES.

Which Contour.	May 1875.	Dec. 1875.	Jan 1876.	Feb. 1876.	Mar. 17, 1876.	Mar. 29, 1876.	April 1876.	May 1876.	July 30, 1876.	Aug. 14, 1876.	Sep. 1876.	Oct. 1876.	Dec. 1876.	Mar. 1877.	July 1877.	Sep. 1877.	Feb. 1878.	Apl. 1878.	May 1878.	July 1878.	Dec. 1878.	Mar. 1879.	July 1879.	Dec. 1879.	Jan. 1880.
12 Feet.....	4,305	2,635	750	0																					
15 "	5,925	4,400	4,175	2,175	450	50	0																		
18 "	7,000	5,692	4,480	3,960	2,575	1,180	750	175	0																
20 "	9,635	6,215	5,425	4,490	3,255	2,955	2,200	720	75	0															
22 "	9,650	9,675	9,650	9,650	7,300	5,270	3,995	1,952	1,350	975	400	100	1,050	325	200	150	0	...							
24 "	10,485	10,400	10,450	10,450	7,950	7,600	5,975	3,120	2,750	2,550	2,450	1,740	5,550	3,000	325	450	225	170	390	0		...			
26 "	10,585	11,225	11,225	11,225	9,600		7,975	5,550	5,650		4,350	4,340	8,650	6,500	2,675	2,400	1,610	300	540	250	540	0			
30 "	11,750	11,700	11,700	11,700	10,900		10,325	8,960	8,695		9,950	9,775	11,150	9,200	6,225	7,250	6,500	4,650	4,550	3,650	6,250	3,525	0		

APPENDIX VIII.

(See page 108.)

LETTER FROM JAS. B. EADS TO THE SECRETARY OF WAR.

NEW ORLEANS, *May* 23, 1876.

HON. ALPHONSO TAFT, *Secretary of War, Washington, D. C.:*

SIR:—My duty to those who have been and are now supplying me with money to consummate the grant made by the Forty-third Congress, compels me, very reluctantly, to call your attention to the inclosed letter (marked A), signed C. W. Howell, Captain of Engineers, U. S. A., dated May 6, 1876, and published in the *Republican* and *Democrat*, of New Orleans.

I desire to submit with it, as briefly as possible, the following facts:

During the Forty-third Congress, two plans for the improvement of the Mississippi were presented for consideration. The one known as the Fort St. Philip Canal was urged chiefly by Gen. A. A. Humphreys, Chief of Engineers, U. S. A., and Major Howell, United States Engineers; and the other, the jetty system, by myself and others. The subject was referred by Congress to a mixed commission, composed of seven distinguished military and civil engineers, who, after careful deliberation, reported (one member only dissenting) in favor of the jetty system: whereupon, Congress granted to myself and associates the right to improve the South Pass, an outlet unused for commerce; the grant expressly stipulating that we are to be paid nothing in case of failure to secure twenty feet depth of channel through the pass to the gulf, within a stated period. The act directs the Secretary of War to appoint an officer "whose duty it shall be to report the depth of water and width of channel secured and maintained from time to time, in said channel, together with such other information as the Secretary of War may direct."

The grant expressly provides that "I shall be untrammeled in the exercise of my judgment and skill in the location, design, and construction of the works," therefore I did not suppose that another officer of engineers, and one, too, avowedly hostile to the undertaking, would likewise (without authority of Congress) be charged with the official duty of observing any part of our work or its results. Least of all did I suppose that he would be permitted to give to the public with perfect freedom such unfavorable and unreliable information respecting it as might best seem to support the predictions of its failure previously uttered so confidently by his chief and himself, and thus really trammel its construction by increasing my difficulties in providing means with which to carry it on.

Anonymous statements circulated in this city, and subsequently sent hence by telegraph, have been published in a number of newspapers through the country, to the effect that a new shoal was forming in advance of the jetties, and that their failure was therefore certain. This report, being persistently repeated, was publicly denounced by me, with perhaps too much feeling, as a "malicious falsehood," but without supposing that Major Howell was at all responsible for the statement. Appreciating the importance, however, of refuting such reports by evidence that could not be challenged, I addressed the Superintendent of the United States Coast Survey as follows:

NEW ORLEANS, *March* 7, 1876.

Capt. C. P. PATTERSON, *Superintendent U. S. Coast Survey, Washington, D. C.:*

DEAR SIR:—Last year Lieut. Marinden made soundings on radial lines seawards from the bar of South Pass. I very much desire that these radial soundings should be repeated before Lieut. M. leaves here, and I think you will agree with me that it is important to know where the one or two millions of cubic yards of sandy alluvion, which have been swept out of South Pass from its bar, have been carried and deposited, and what changes, if any, have occurred in the contour lines off the mouth of South Pass.

Radial lines of soundings should be made from the east and west lands' ends out to two or three miles off shore.

Hoping that you will kindly oblige me by ordering this work to be done by Lieut. M., I remain, with sentiments of high esteem, yours very truly,

JAS. B. EADS.

In answer I received the following reply:

U. S. COAST SURVEY OFFICE,
WASHINGTON, *March* 10, 1876.

DEAR SIR:—Yours of the 7th is just received.

Authority will be given to Assistant Marinden to run such radial lines as you may wish, but as he has not the control of a steam launch this season, only his boats avail for the purpose, and consequently he should run merely such lines as may be absolutely necessary.

If you could furnish him the use of a small steamer, the work could be executed more rapidly, and doubtless with more satisfaction to you and himself.

The state of our funds does not enable us to incur the expense of a steamer.

* * * * * *

Yours respectfully,

C. P. PATTERSON,
Sup't U. S. Coast Survey.

JAS. B. EADS, C.E., New Orleans, La.

I agreed to furnish the necessary steamboat, and these soundings have now been nearly completed.

On the 26th ult. a large party, comprising many influential gentlemen, visited the jetties on the mammoth steamer *Grand Republic*. It was stated in

the New Orleans *Times*, after the return of the boat to New Orleans, that an assistant of Major Howell had gone on board the boat at the jetties, with a chart of soundings just taken by him, which he exhibited and explained to the passengers. I was assured by several prominent citizens of New Orleans, whose names will be given if desired, that his apparently reliable and official statements had created great distrust in the ultimate success of our work throughout the whole city, as it was generally believed Maj. Howell's surveys revealed a rapidly forming shoal in advance of the jetties. I was reliably informed that a large amount of stock subscribed in aid of our undertaking was actually offered at the time at half its cost in consequence, and I myself received at the same time a letter asking the release of one of the parties aiding it, from his obligation to pay a large balance due on his subscription.

Knowing the importance of promptly refuting by official testimony these misrepresentations, I immediately addressed the following additional request to the Superintendent of U. S. Coast Survey:

PORT EADS, LA., *April* 27, 1876.

Capt. C. P. PATTERSON, *Washington, D. C.:*

DEAR SIR:—As the changes within our jettied channel have been very great since Assistant Marinden surveyed the bar, I would respectfully suggest the importance of having his party sound the depth within the jetties and within a thousand feet of their mouth.

This work can be done with much greater ease and much quicker now than before, as I have signal ranges and stations established by which my assistant engineers make these soundings in two days' time generally. I will be much obliged if you will order this work to be done as early as possible, and instruct Assistant Marinden to furnish me a copy of the results. He is now here preparing for the radial soundings beyond the jetties. I will loan him facilities for all the work.

* * * * * *

Very respectfully,

JAS. B. EADS.

Feeling indignant and outraged at the unwarranted conduct of Maj. Howell's assistant, I published a letter in the New Orleans *Times*, herewith inclosed (marked B), in which I again pronounced the reported shoaling in advance of the jetties as absolutely false. I had, however, so much confidence in Major Howell's honor, and in the delicate sense of propriety which characterizes gentlemen of the army, that I exonerated him in the following language, in the letter, from any complicity in this effort to injure me and my associates. I said:

"But as these works are not under the supervision of Major Howell, it is unjust to him to infer that he has authorized any of his assistants to make an 'official' survey of the South Pass bar at the Government's expense, or that he would countenance on the part of his assistant any effort to create in the minds of the visitors by the *Grand Republic*, or in those of any other persons whatever, the false impression that this bar, which has thus far been removed by the effect of the jetties, is being reformed in advance of them, or that he would, as readers of your editorial might possibly suppose, permit the draft of

ch soundings to be exhibited on the *Grand Republic* or in his office with any ow of 'official sanction.'"

An editorial herewith inclosed (marked C) shortly after appeared in the ew Orleans *Democrat*, containing statements that could only have been ob- ined in Major Howell's office, and which apparently sustained this false port. I immediately answered the editor of the *Democrat* by letter, a copy which is herewith inclosed (marked D), that this and similar reports had eir origin either in ignorance or malice, as they were absolutely untrue. I id not, however, even then charge Major Howell with being the author or prompter of them.

This second letter was followed by the publication of the inclosed objec- tionable letter of Major Howell, before referred to. Major Howell declares in this letter:

"On my own part this considerate silence would not have been broken but for the recent insidious attacks of Mr. Eads, and after this date I shall feel at liberty to either repel further attack or let the violence of Mr. Eads of itself gradually disgust the public."

As "the recent insidious attacks of Mr. Eads" seem to be the only justifica- tion offered by Major Howell, you will, after reading my published letters herein referred to, be able to judge of the merits of this excuse. Of course I cannot reply to Major Howell's personalities, for when an officer of the army makes statements that are untrue, and uses his official signature to give them additional weight, discussions that might otherwise be justified between us are at once forbidden. These untrue statements are as follows:

"The fact is, that on the day of the *Grand Republic* splurge there was at South Pass only a channel of twelve feet entitled to be called navigable, while at Southwest Pass there was a navigable channel of over eighteen feet."

"I know that on the day the *Grand Republic* visited South Pass the nucleus of a new bar existed 1,000 feet in front of the jetties, and that a shoal had made out from the end of the west jetty 380 feet towards this, and diagon- ally across the front of the jetties."

"I know that since the commencement of the jetty work the low water cross section of South Pass, one mile below its head, has been diminished one-sixth; that the velocity at this point has relatively decreased, and that the volume of discharge of the pass which, before commencement of the jetties, was found to be fifteen per cent. of the total discharge of the three passes, is now but eleven per cent. Mr. Eads has probably discovered these facts, hav- ing such a serious bearing on the ultimate success of his work, and knowing that they will soon be made public through official channels, seeks in advance to break their force by crying out 'malice,' 'falsehood,' etc."

A direct and positive refutation of four of these untrue and injurious state- ments will be found in the following letters from three of the gentlemen assisting me in the engineering department of the work, and who are no less respected for their veracity than for their professional abilities.

NEW ORLEANS, *May* 22, 1876.

Capt. J. B. EADS, *Chief Engineer South Pass Jetty Works, New Orleans, La.:*

DEAR SIR:—The statements of Major Howell, United States Engineers,

contained in his letter recently published respecting this work, having been referred by you to me for examination, I have to state that there has been no shoaling in advance of the jetties, but, on the contrary, there has been a very marked and general increase in the depth immediately in front of the outer slope of the bar in advance of the jetties, as far out as we have made accurate examinations, nearly 2,000 feet beyond the jetties. I am able to assert this in the most positive manner, as we have a number of carefully located ranges covering the bar and the deep water in front of it, and I have made careful soundings all over it at least once and sometimes twice a month for several months past, each sounding at the moment it was taken being located instrumentally from fixed and well verified points of observation. I am able to state positively that there has, at no time since we commenced work, been any shoal making out diagonally from the west jetty toward the so-called "nucleus of a new bar" in advance of it, as stated by Major Howell.

I can also state positively that what he terms "the nucleus of a new bar," one thousand feet in front of the jetties, is the remains of a lump shown on the Coast Survey map before we began the jetties, and from approximately correct estimates made by me, after comparing, as carefully as possible, the depths over it a year ago, with those now existing on it, that the cubical contents of it above a plane thirty feet below the mean level of the gulf, have diminished nearly one-half. The depth on the shoalest part of it, which is a mere point or apex, was last year fully three feet less than it is at present. This lump seems to be soft, tenacious clay. It has deep water all around it, and constitutes no impediment to the safe and easy navigation of the jettied channel.

I have further to state, that I have made recent soundings across the South Pass, one mile below the head of it, at the point referred to by Maj. Howell, and compared them with those of the Coast Survey of last year. I find no such diminution of its section as Maj. Howell has stated. It has certainly not decreased at this point, since the jetties were commenced. I have also made careful soundings across the pass below Grand Bayou, before the section of the bayou was reduced by the dam now partially completed, and which now throws an additional quantity of water into South Pass, and found it considerably larger than the size shown by Coast Survey soundings made last year.

I would further state that on the day when the *Grand Republic* visited the jetties, there was a navigable depth of fully sixteen feet entirely through the jetties at high tide. It was measured by myself and several other persons on that day and the day previous.

Very respectfully, etc.,

E. L. CORTHELL,
Chief Assistant Engineer.

I fully concur in the statements made by Mr. Corthell, and certify to their correctness. I myself superintended the taking of a line of soundings into the pass between the jetties, on the day the *Grand Republic* visited Port Eads, and in no place found a less depth, at average high water, than sixteen feet, with only one place so shoal as that.

Very truly yours,

G. W. R. BAYLEY,
Resident Engineer.

NEW ORLEANS, LA., *May* 22, 1876.

PORT EADS, LA., *May* 23, 1876.

. JAS. B. EADS, *New Orleans, La.:*

have assisted Mr. E. L. Corthell in all the surveys that have been made r his direction at the mouth of South Pass. I have mapped them out ully, and from my own studies of the changes that have occurred inside outside the jetties, I can fully indorse Mr. Corthell's statements, and tes- to their correctness.

Very respectfully, your obedient servant,

MAX E. SCHMIDT,
Assistant Engineer South Pass Jetty Works.

bout the time Maj. Howell published his letter, I received the following teous refusal of my second request from the Superintendent of the Coast ey:

UNITED STATES COAST SURVEY,
WASHINGTON, D. C., *May* 1, 1876.

EAR SIR:—Your letter of April 27th is duly received. I would cheerfully ly with your wishes, but the law expressly provides that the inspecting r of the Engineer Corps (Gen. Comstock) shall execute the class of sur- you wish within the jetties.

he radial lines from the outer ends of the jetties were run at your request, he purpose of finding, if possible within their limits, the deposit of re- d material.

shall be glad to offer any assistance in my power to Gen. Comstock, ld he express a wish for the survey to which you refer.

Yours respectfully,

C. P. PATTERSON,
Sup't U. S. Coast Survey.

B. EADS, Esq., *New Orleans.*

mmediately after the visit of the *Grand Republic*, Capt. Brown, U. S. neers (assistant of Gen. Comstock), commenced a survey of the bar, and ving that information in his possession would completely refute Major ell's assertion, I asked him for an official statement of the depths of chan- t that time. This he declined to give, stating as a reason that he had nade his report to Gen. Comstock. Learning that the latter officer had gone to the jetties, I telegraphed the Secretary of War as follows:

NEW ORLEANS, LA., *May* 9, 1876.

. ALPHONSO TAFT, *Secretary of War, Washington, D. C.:*

lease instruct Gen. C. B. Comstock, now at Port Eads, to sound channel een jetties with me; likewise dredged channel through Southwest Pass and furnish me with the results promptly. Major Howell has published a tatement, affecting public confidence in my work, and this information is ired in justice to myself, and will benefit the public.

JAS. B. EADS.

I proceeded to the jetties, and met Gen. Comstock on his way back. I urged his return, that he might measure the channel with me, if so authorized by the Secretary of War. On my urgent declaration that a wrong had been done me, and one that was seriously affecting the prosecution of the work, Gen. Comstock consented to return, and remained during the day at the jetties awaiting instructions; but as no answer to my dispatch came, he left that evening for New Orleans. He declined to give me any information respecting the depths in question, for the reason that he had not yet made his report to Gen. Humphreys. Four days after sending my dispatch to the Secretary of War, I received the following telegram:

WASHINGTON, *May* 13, 1876.

Mr. JAS. B. EADS, *New Orleans, La.:*

In accordance with the law, Gen. Comstock received authority and instructions for complete survey and examination of the South Pass improvement before leaving Detroit. A copy of the results of his soundings will be furnished as soon as received.

ALPHONSO TAFT.

On receipt of this telegram I dispatched to the Superintendent of the Coast Survey, requesting that Mr. Assistant Marinden be permitted to inform me of the result of his soundings just made, chiefly at my own expense, in advance of the bar. In reply I received the following telegram:

WASHINGTON, *May* 16, 1876.

Capt. JAS. B. EADS:

Regret Marinden cannot furnish his results. Gen. Comstock will give all information required by law. Will write.

C. P. PATTERSON,
Sup't, etc.

It will be seen that I have been unable at the end of three weeks to obtain from any Government officials the facts in their possession or control, with which to defend this enterprise from the persistent and injurious misrepresentations which have appeared anonymously, semi-officially, and authoritatively during the last few weeks, and that I have been refused the request to direct Gen. Comstock, when on the spot, to measure and certify to me the depth of channel, to right a wrong done by his brother officer. In prominent contrast with the difficulties I have encountered in getting this official information, which would have been of great value to me if promptly obtained, I quote the following from the letter of Major Howell regarding his surveys:

"The surveys have been made at government expense, because needed to aid in solving the great problem presented at the mouth of the Mississippi.

"If the results had been available before the passage of the jetty contract, it is probable that the country would not have been saddled with the adventure.

"My charts, observations for velocity of currents, amounts of material carried in suspension by the river water, and volumes of discharge, have always been open for the inspection of any courteous gentleman interested in seeing them. In this there is no impropriety, as Mr. Eads would insinuate."

I have no reason whatever to complain of the course pursued by Capt. Patterson, Gen. Comstock, or Capt. Brown in this matter, as it has been, I believe, in strict accordance with official propriety.

Major Howell says:

"I know that between distances two and a half and seven and a half miles seaward of the outer end of his jetties, the gulf has shoaled at a rate which, if continued, will in eighteen high-water seasons bring the gulf bottom to the surface, and necessitate the prolongation of the jetties at least seven and a half miles."

When it is understood that this reputed shoaling was known before the jetties were commenced, and that no soundings have been made over it since last November, to determine whether it is increasing or diminishing, at which time the eroding action of the jetties had scarcely begun, its "serious bearing upon the ultimate success of his (my) work" can be estimated, as well as the fairness of the writer in leaving his readers to infer that this shoaling is an evidence of the truth of the prediction of himself and his chief regarding the reformation of the bar.

An extension of the jetties of seven and a half miles in eighteen years, or nearly six feet per day, would not be incompatible with the following assurance given to the New Orleans Chamber of Commerce by Major Howell, and which will be found in his letter to Mr. J. H. Oglesby, president, that, as no littoral current exists at the mouth of the Mississippi, "jetties would have to be built further and further out, not annually, but steadily every day of each year, to keep pace with the advance of the river deposit into the gulf, provided they are attempted, and the attempt warranted by having the relative character of bed and banks favorable."

I quote again from Major Howell's inclosed letter as follows:

"Holding these views, no army engineer has thrown a straw in the way of Mr. Eads's jetty work."

This is another misstatement. *After the jetty system was finally adopted by the last Congress*, Gen. Humphreys published four essays, termed by him "memorandums," to prove that the jetties would be a failure; these were published as a part of his official report to the present Congress. They were at the same time extracted from that voluminous document and illustrated with maps, were bound in pamphlet form and distributed throughout the country five months ago. To counteract the injurious effect of these private opinions of Gen. Humphreys, to which he gave all the weight of his official titles and position, I deemed it necessary to expose the fallacies upon which his arguments were founded, by reviewing the United States Levee Commission's report, which was based upon the same unsound theories, and to which report he had given his emphatic approval.

Major Howell endeavors to excuse this conduct of his chief in the closing words of the following extract:

"Since the passage of the late jetty contract, those opponents of the experiment who took part in the discussions preceding the passage of the contract, considered, first, that they were in no way responsible for the experiment. Second, that further discussion would be useless, except so far as required to complete that left unfinished by the action of Congress."

Admitting Gen. Humphreys's ability to complete discussions left unfinished

by Congress, his justification in this case would have been more satisfactory had Major Howell informed his readers by what authority an officer of the United States Engineers presumes to publish his gratuitous opinions at the public expense, or to indirectly criticise the President and Congress of the United States for declining to be guided by the judgment of Gen. Humphreys and Major Howell in this matter.

But few persons inexperienced in the difficulties of raising the large amounts of money required in works of great magnitude, can appreciate the injurious effects of unfavorable arguments or apparently well authenticated reports against an enterprise, especially when they involve, if correct, the certain loss of capital invested. For several weeks past we have, through the self-acknowledged conduct of Major Howell, been seriously trammeled in the prosecution of the works we are constructing, by misrepresentations to which have been given a real or seeming assurance of official truth, while it has been out of my power to obtain, officially, the real facts to disprove them.

In view of the annoyance and embarrassments already suffered from the official antagonism of Gen. Humphreys and Major Howell, and of the fact that their official positions give them the ability to continue their open or insidious opposition to this work (the one being Chief of the Corps of Engineers, U. S. A., and the other stationed in this city in charge of important engineering operations in the vicinity), I have to respectfully ask that any further officious or unauthorized official interference on the part of these officers be interdicted, and that instructions be issued to the inspecting officer authorized by the act, and "detailed" by you to make the examinations, to promptly supply me with any official information he may from time to time acquire respecting these works and their results, which I may deem important to facilitate us in carrying out the intent of the grant, or in protecting us from misrepresentation; and that his reports hereafter be made directly to the Secretary of War, instead of through the medium of the Chief of Engineers, U. S. A., as the Secretary of War alone is, by the words of the grant, "authorized and directed to carry into effect the provisions of the act."

We are assuming all risks and expending our own money under a grant which gives us no power to deceive the government, even if we desired to. Our compensation depends wholly upon results to be achieved, and upon the good faith of the government. We were entitled to eight months to commence the work, and thirty months within which to secure twenty feet of depth, yet before fifteen have elapsed the largest coasting steamers trading to New Orleans have been sent to sea over the bar on which scarcely eight feet of water could be found last year. We have thus shown an energy and good faith not only entitling us to the moral support of the government, but to its confidence. I cannot believe for a moment that the policy of your department will, with your sanction, be allowed to embarrass me in the prosecution of a work of such immense importance, when the untrammeled control of it was confided to me by the almost unanimous action of Congress, and the approval of the President of the United States.

I have the honor to be, very respectfully,

Your very obedient servant,

JAS. B. EADS.

"A."

[From the New Orleans *Democrat*, May 6, 1876.]

UNITED STATES ENGINEER'S OFFICE,
NEW ORLEANS, LA., *May* 6, 1876.

EDITOR DEMOCRAT:—Your editorial of the third instant, elicited by the lengthy telegram of James B. Eads, which appeared in the New Orleans *Times* of April 30th, has provoked Mr. Eads into writing a letter (published in your issue of the 4th inst.) which is calculated to create a wrong impression on the minds of the public.

Mr. Eads is mistaken in supposing that because he has a contract to try to improve South Pass, this fact bars me from continuing to completion a series of surveys made, commenced under orders received two years ago. The series would have been incomplete without the recent gauging of the passes and reconnoissance of South Pass bar.

The results, when fully submitted to the public, will greatly interest hydraulic engineers, and go far toward refuting many of the absurd statements and theories advanced by Mr. Eads before commencing his jetties, and on which all his specious plans are based.

Perhaps this is the reason why, in his usual brow-beating manner, with which the people of New Orleans are so familiar, he attempts to choke off investigation.

The surveys have been made at government expense, because needed to aid in solving the great problem presented at the mouth of the Mississippi.

If the results had been available before the passage of the jetty contract, it is probable that the country would not have been saddled with the adventure.

My charts, observations for velocity of currents, amounts of material carried in suspension by the river water, and volumes of discharge, have always been open for the inspection of any courteous gentleman interested in seeing them. In this there is no impropriety, as Mr. Eads would insinuate.

The insinuation in regard to the St. Louis telegram is one that no just man would give such publicity to without first satisfying himself as to the facts. I have not seen a copy of the telegram; do not know what it contained; but I know this, that if the information on which it was based came from my office, and was honestly used, instead of being, as styled, a "malicious falsehood," it was the unpalatable truth.

The more direct charge, that my assistant endeavored to create among the guests and passengers of the *Grand Republic* an impression unfavorable to the jetties, is equally without foundation.

After investigating the matter, I find these to be the facts: Mr. Collins, having completed his field work, in accordance with his instructions to return to New Orleans as soon as possible, took passage on the *Grand Republic*, paid his fare, simply answered questions when courtesy required it, and was an interested observer of the solemn farce entitled "Col. Andrews's examination."

There was no volunteered attempt on his part to influence the minds of the St. Louis delegation against their "Josh," his work or his teachings.

By implication, the accuracy of the work done by my assistants has been brought in question.

Mr. Collins has been with me over four years. He has worked in the field with three of my military assistants, who report him to me as an accurate, rapid, and extremely conscientious engineer. I place full faith in his reports.

The results of dredging at Southwest Pass are very unfairly presented.

The reported mean low tide depth at Southwest Pass is introduced in such artful connection with a reported high tide depth at South Pass, that the casual reader would be led to think the depth of channel at the two passes the same; whereas, the fact is, that on the day of the *Grand Republic* splurge there was at South Pass only a channel of twelve feet entitled to be called navigable, while at Southwest Pass there was a navigable channel of over eighteen feet.

Now, let me give my understanding of the position held by Mr. Eads and the opponents of his jetty attempt. It may give the public something worth thinking over.

I know that between distances two and a half and seven and a half miles seaward of the outer end of his jetties the gulf has shoaled at a rate which, if continued, will in eighteen high-water seasons bring the gulf bottom to the surface, and necessitate the prolongation of the jetties at least seven and a half miles.

I know that on the day the *Grand Republic* visited South Pass the nucleus of a new bar existed one thousand feet in front of the jetties, and that a shoal had made out from the end of the west jetty, three hundred and eighty feet toward this and diagonally across the front of the jetties.

I know that since the commencement of the jetty work the low water cross section of South Pass, one mile below its head, has been diminished one-sixth; that the velocity at this point has relatively decreased, and that the volume of discharge of the pass which, before commencement of the jetties, was found to be fifteen per cent. of the total discharge of the three passes, is now but eleven per cent. Mr. Eads has probably discovered these facts, having such a serious bearing on the ultimate success of his work, and knowing that they will soon be made public through official channels, seeks in advance to break their force by crying out "malice," "falsehood," etc.

Since the passage of the late jetty contract, those opponents of the experiment who took part in the discussions preceding the passage of the contract considered, first, that they were in no way responsible for the experiment. Second, that further discussion would be useless, except so far as required to complete that left unfinished by the action of Congress. Third, that as the experiment had been decided upon, it was every way desirable that it should be carried to completion, in order that a question which has embarrassed the mouth of the river problem for forty years, and which might do so for an indefinite time to come, should be practically settled one way or the other, beyond resuscitation.

Holding these views, no army engineer has thrown a straw in the way of Mr. Eads's jetty work.

His "outside speculations" regarding the closure of the "Jump" and "Cubit's Gap," and his crude ideas about the improvement of the upper river, have been criticised, but his jetty adventure has been let alone. It now appears that it has been let too much alone to suit his present purposes.

On my own part, this considerate silence would not have been broken but for the recent insidious attacks of Mr. Eads, and after this date I shall feel at

liberty to either repel further attack or let the violence of Mr. Eads of itself gradually disgust the public.

In closing, I offer an opinion, which perhaps I am not alone in holding.

The repeated cries of "success" which we have heard from the very commencement of the jetties are deceitful. There can be no success except of a United States Treasury raid until it is ascertained that the jetties are of a permanent character, and afford something more than a temporary outlet to the commerce of the Mississippi valley.

I am, sir, very respectfully yours,

C. W. HOWELL,
Capt. of Engineers, United States Army.

"B."

[From N. O. *Times*, 30th April.]

[Special Telegram to the *Times*.]

PORT EADS, *April* 29, 1876.

EDITOR NEW ORLEANS TIMES:—In reading your editorial of Friday morning, I observe that in alluding to the soundings made through the channel across the bar of the South Pass, in the presence of Captain Thorwegan and a number of distinguished passengers on the *Grand Republic*, you say, "From this it seems plain that a vessel drawing sixteen feet can go to sea through the jetties at mean low tide any day." * * * * * "All this was very gratifying and encouraging to the visitors. Only one ugly feature was to be observed, and that was a draft of soundings made by an assistant of Capt. Howell on the morning of the same day, which draft is said to be now in Capt. Howell's office." You state in the editorial that this draft of Capt. Howell's assistant shows soundings four hundred feet out from the sea end of the jetties, and that the water shoals up there suddenly to sixteen feet. You add these words, "Assuming these soundings to be official and correct, the general impression would be that a new bar is forming, not on the sea slope of the old one, but on the other side of a narrow sound, across which the swift current of the river carries its sediment to be suddenly dropped at a certain distance out. This is a very disagreeable feature of the case, and we sincerely hope it may be satisfactorily explained away. If it cannot, the sooner the fact is known the better." It is only two days ago that I authorized the Secretary of the South Pass Jetty Company to state in reply to telegrams sent from New Orleans to St. Louis, and published in the papers of the latter city, "that the reported shoaling in front of the jetties was a malicious falsehood." I was justified in thus emphatically expressing these anonymous misrepresentations, by recent soundings carefully made by my assistant engineers, within a thousand feet of the sea end of the jetties and beyond the bar.

These soundings were carefully located by instruments, and were compared with those made one year ago by the United States Coast Survey. They prove conclusively that there has been a general deepening in advance of the bar in

front of the jetties, precisely where Gen. Humphreys, Major Howell, and other opposers of the jetty system predicted a reformation of the bar. The deepening is shown by these soundings to be several feet in depth over an area of 1,000,000 square feet beyond the outer slope of the bar. At my solicitation, the Superintendent of the United States Coast Survey, Capt. C. P. Patterson, has instructed Assistant Marinden, United States Coast Survey, who made the survey last year, to run out radial lines of soundings from the sea ends of the jetties to a distance of three miles, or into about thirty fathoms of water, for the purpose of ascertaining what deposit has been made within that distance since we commenced work. This duty Mr. Marinden is to-day performing, and the results will, I presume, be promptly furnished to the public by the Superintendent of the Coast Survey, through the proper department. The steamer employed in this service is furnished by me. The cause of the remarkable deepening, which our soundings have discovered immediately in advance of the bar, is attributed by me to the fact that the river current, now concentrated between the jetties, is a strong, bold stream, from 12 to 16 feet deep, possessing such momentum and force that the prevailing westerly sea current, which intersects it nearly at right angles, is forced beneath the river discharge, and has excavated for its own accommodation an increased depth on the sea slope of the bar. Before we began work, the river discharge constituted but a feeble and shallow film of water, several thousand feet wide and only two or three feet in average depth, and would oppose but little resistance to the sea current. With this dispatch, I have directed to be handed to you a lithographic plat of the United States Coast Survey soundings of last May, on which are shown the jetty lines also; several hundred copies of these charts have been sent by me during the past six months to parties interested in the enterprise, with our own soundings marked thereon, to show them the changes in depth from time to time. You will see from this chart that about 800 feet in advance of the jetty line the Coast Survey soundings show a small shoal spot, on which there was then only twelve feet of water. Upon the shoal Capt. Howell's assistant, it seems, found 16 feet last Wednesday. As the greatest depth across the crest of the bar is only claimed to be 16 feet 4 inches, it would seem unreasonable that the river current should have scoured off more than three or four feet of this shoal 800 feet in advance of the bar crest, because the river current cannot act outside the jetties at any greater depth than that at which it flows on over the bar crest, the river water being of lighter specific gravity than that of the sea.

This depth of 16 feet, which really is on this spot to-day, indicates the very opposite of what you fear, and what the jetty opposers so emphatically declared would occur. It does not indicate in the slightest degree any reformation of the bar beyond the jetties, but, on the contrary, it proves that so fast as the compact current of the river deepens the crest of the bar, it likewise cuts down this solitary lump, which the Coast Survey sounding of last year discovered in the deep water of the gulf immediately in advance of the jetties, which will disappear in due season, and which to-day has from thirty to forty feet of water all around it. I was informed that Major Howell's steam *Survey* launch had come around into South Pass on the day the *Grand Republic* was expected here, and that his assistant had taken some random soundings through the jetties at that time, and that a draft of these soundings was

exhibited to the passengers of the *Grand Republic*, which you say "was the only ugly feature of the occasion." But as these works are not under the supervision of Major Howell, it is unjust to him to infer that he has authorized any of his assistants to make an "official" survey of the South Pass bar at the government's expense, or that he would countenance on the part of his assistant any effort to create in the minds of the visitors by the *Grand Republic*, or in those of any other persons whatever, the false impression that this bar, which has thus far been removed by the effect of the jetties, is being reformed in advance of them, or that he would, as readers of your editorial might possibly suppose, permit the draft of such soundings to be exhibited on the *Grand Republic* or in his office with any show of "official sanction."

JAS. B. EADS.

"C."

[From New Orleans *Democrat*, May 3.]

THE JETTIES.

OFFICIAL FACTS, AND FIGURES ABOUT THEM.—HOW THE DEPARTMENT OF UNITED STATES ENGINEERS OBTAIN THEIR SOUNDINGS.

Capt. Eads comes out in a communication to the *Times*, in which he reiterates his assurances concerning the condition of the jetties, and refutes the statements of other people; and he takes occasion to say that he has instructed the Secretary of the South Pass jetties to state in reply to telegrams from New Orleans to St. Louis, "that the reported shoaling in front of the jetties was a malicious falsehood." Further on, Capt. Eads says: "But as these works are not under the supervision of Maj. Howell, it is unjust to infer that he has authorized any of his assistants to make an official survey of the South Pass bar at the government's expense, or that he would countenance on the part of his assistant any effort to create in the minds of the visitors by the *Grand Republic*, or *in those of other persons whatever*, (the italics are ours) the false impression that this bar, which has thus far been removed by the effect of the jetties, is being reformed in advance of them, or that he would, as the readers of your editorial might possibly suppose, permit the draft of such soundings to be exhibited on the *Grand Republic*, or in his office, with any show of 'official sanction.'" Certainly, in penning the above quotations taken from his communication, Capt. Eads was reckoning without his host, as the saying is, and his deductions in the last paragraph must fall to the ground when he is informed that the drafts of the soundings of Maj. Howell's assistant, Capt. Collens, are exhibited in his office with a considerable show of "official sanction." In fact, the soundings are made "officially" at the government's expense, and are part of a series of coast surveys which are under Maj. Howell's supervision, although the jetty works may not be, and if Capt. Eads doubts the truth of this statement, he can visit the office of Maj. Howell and satisfy himself. He will find there charts made from time to time of the South Pass, of so elaborate a character, that he will confess that by comparison his own lithographed charts must pale before them. It is useless to refer to the "malicious false-

hood" portion of Capt. Eads's communication, in so far as it might affect those "other persons whatever," also spoken of by him. These utterances were made under circumstances which exist no longer, since it is now told to Capt. Eads that the reports, or some of them at least, were based on the "official" figures of the Engineer Department. That Capt. Eads is entitled to belief when he asserts that his soundings are true, nobody will deny, but credit is also due to Maj. Howell and his assistants in the same relation. If, however, the question of correctness is raised on the score of favor or opposition to the jetty system, Mr. Eads's position becomes delicate, but that of Maj. Howell remains unchanged, whatever may occur in the case of the opposers of the system. Capt. Eads is largely interested in the success of the jetties. His money and that of his friends, to the tune of several hundred thousand dollars, is jeoparded, and his reputation is involved. He has everything to lose. Maj. Howell, like all engineers of his ability, may and must have his theory on the subject, but he has neither money nor reputation involved. He is simply performing a duty. If, in performing this duty, the results conflict with those obtained by Capt. Eads, there can be no impropriety on the part of the department engineers to give access to their records, when politely requested to do so.

Now, to facts; they are few but important. During last week, as was stated in the *Democrat*, Capt. Collens was engaged in taking soundings of the Pass, and yesterday had already compiled and collated a good portion of his work. This compilation shows that the west end shoal, which a year ago was 800 yards beyond the end of the jetty, was, on the 26th of April last, thrown out to 1,000 yards, and from the radial soundings taken by the same officers, exactly 380 feet out of the jetties; the bar has simply been pushed out, slope, shoal and all, as though it had been bodily removed from one point to another, showing, however, a difference in favor of Captain Eads, at the crest of the present bar, of something like a foot in depth of water. But it is shown by the profiles that the crest of the shoal, as it existed a year ago, was a mere peak, the crest of which has easily ceded to attrition. Again, it is shown by the same profile that the breadth of the shoal, as it is now, is considerably increased, and hence will require more force to be removed than previously.

That the soundings have been carefully and elaborately made by the United States engineers will be understood when it is said that they have been made in ten longitudinal sections, one hundred yards wide each (the width of the jetties being one thousand yards), according to the regulation instructions of the War Department. The profiles are complete, and with their aid, and after making all due allowances, Major Howell has traced a possible fifteen foot channel to the west end of the jetties, where the depth on the shoal is about sixteen feet. He has, however, been unable to trace a similar channel to the east end, where the depth of water is far greater.

As to the volume of discharge upon which Captain Eads depended so much to scour out the channel of the jetties, Major Howell's belief that it had diminished in the South Pass and increased in the Southwest Pass has been verified by actual measurement. The velocity was taken one mile below the head of South Pass and below Grand Bayou. In Southwest Pass it was taken at Scott's, two and a quarter miles below the head of the pass. Major Howell's assistants have besides discovered, also by accurate measurement, that the in-

crease in the area of water in Southwest Pass was, on the 26th of April, fifteen per cent. above last year's measurement, while in South Pass the increase was only one-tenth, notwithstanding that the Mississippi is much higher at this period than when the measurements were taken last year.

In connection with the condition of South Pass, the following is given, showing that of Southwest Pass:

UNITED STATES ENGINEER OFFICE,
NEW ORLEANS.

MEMORANDUM.

During the month of April, 1876, the depth of the channel at Southwest Pass, at mean low tide, was 16 feet, with a least width for that depth ranging from 40 to 100 feet.

High tides ranged above mean low tide from 2 to 2¼ feet, making the depth of channel at high tide range from 18 to 18¼ feet.

The dredge-boat *McAllister* worked on the bar during the month eighty-one hours and fifty minutes.

The following number of vessels crossed the bar during the month:

Steamers in	27
" out	24
Sailing vessels in	41
" " out	92
Total	184

Of these sixteen drew from 18 feet to 18 feet 9 inches. Of this number, nine, drawing 18 feet and over, were detained an aggregate of seventy-six hours; seven, drawing less than 18 feet, were detained an aggregate of one hundred and thirty-one and a half hours.

"D."

[From the New Orleans *Democrat*, May 4.]

LETTER FROM CAPT. EADS.

THE JETTIES SEVENTEEN FEET ON THE BAR.—A PERMANENT INCREASE IN THE DEPTH ON SOUTH PASS BAR.

NEW ORLEANS, *May* 3, 1876.

Editor *Democrat*:

DEAR SIR:—I have read your article in this evening's *Democrat*, by which your readers are informed that official soundings of the South Pass bar have been elaborately made by Major Howell, United States Engineers. You say: "In fact, the soundings are made officially at the government's expense, and are a part of a series of coast surveys which are under Major Howell's supervision, although the jetty works may not be."

This is the first declaration I have seen published to the effect that Major Howell, United States Engineers, is also making official soundings of the pass, and your editorial seems to go into such details as to leave but little

doubt that you have obtained your information from his office, as you say if I will go there I will find "charts there, made from time to time, of the South Pass of so elaborate a character that he (I) will confess that, by comparison, his (my) own lithographed charts must pale before them."

Gen. C. B. Comstock, United States Engineers, was appointed by the Secretary of War to discharge the same duty which, it seems by your editorial, is being performed by Major Howell and his assistants. Gen. Comstock's assistant, Capt. M. R. Brown, United States Engineers, and party were yesterday engaged at the jetties in making elaborate soundings by order of the War Department also, and radial soundings, immediately in advance of the jetties, are likewise being made by the United States Coast Survey.

Elaborate soundings are made at least once a month, and sometimes twice per month, by my Chief Assistant Engineer, Mr. E. L. Corthell, assisted by Mr. Max E. Schmidt and Mr. W. L. Webb, civil engineers, the results of which have from time to time been promptly published by me. It would seem, therefore, that between the cost to the government and to myself and associates, the public are likely to be well informed upon the subject.

There seems to be, however, considerable discrepancy, by your statement, between the results of Major Howell's and my own soundings on the bar; and especially respecting the reformation of the bar in advance of the jetties.

On the appearance of anonymous telegrams in the St. Louis papers, sent recently from this city, stating that the water was shoaling in advance of the jetties, I authorized the emphatic declaration to be made by the South Pass Jetty Company's Secretary in that city, that this report was a "malicious falsehood." I say so still, although it seems less anonymous than before.

Your editorial leaves but little doubt of the fact that you have been misled by information derived from Major Howell's office. You say, "This compilation shows," among other things you mention, "that the bar has simply been pushed out, slope, shoal and all, as though it had been bodily removed from one point to another," etc. To this I have only to reply that any "compilations," or charts of soundings, showing any such result as this, are absolutely false and unreliable.

The contour lines of soundings on the outer slope of the bar embrace between the width of the jetties 1,000 feet, and these lines have frequently altered, sometimes receding on the east side of this width and advancing on the west, and again retreating and advancing on the opposite sides; and again, these lines have retreated and advanced in the middle of the jetties, leaving nearly equal depths on each side of a middle ground at their mouth. On the 25th ult. we had a channel of nearly equal depth on each side of such middle ground, while on this latter, the depth was but two or three feet less than in these channels. Last Sunday the depth in the east one was sixteen feet, and in the west sixteen and a half feet, while but thirteen feet was over the shoal between them. At no time, however, have these contour lines advanced on one part of the bar front without retreating on some other, and there has not been, and is not to-day, any average advance all over the front of the bar. At no time has any part advanced anything like so much as you assert. The eighteen foot contour line, for instance, is not to-day further seaward than it was a year ago, while the deeper contour lines have nearly all retreated; that is, have come further landward, making the outer slope of the bar steeper

han ever before; while beyond the thirty foot contour line the deepening has een very decided, ranging from one to fifteen feet. I repeat therefore, em-hatically, that the reported shoaling in front of the jetties, or the reformation f the bar on its sea slope—a phenomenon confidently predicted by Major Howell and other opposers of the jetty system—*has not occurred*, and that the ffort now being made to create this belief is founded in ignorance or malice.

The cavilers at this improvement declare they have come through the etties and found places with but ten or twelve feet on them, when we have eported fifteen or sixteen. They ignore the fact that the jetties are 1,000 eet wide, and expect to find the maximum depth from jetty to jetty, yet raise the channel maintained by the dredge-boat at Southwest Pass to a legree that makes it surprising that any one should want a better one, al-hough a deviation of thirty feet from its centre gives but fifteen feet or less, nd within a distance not one-quarter of the width of the jetties there is but ight or nine feet.

The persistent misrepresentations and hostility shown by a portion of the itizens and press of this city to this enterprise, is one of the most unexpected nd remarkable features developed by it. I was led to believe that every in-elligent citizen of New Orleans wanted deep water at the mouth of the river. came here with the authority of Congress to improve the shallowest one of he passes, and one not at all used for commerce, and having at high tide carcely more than eight feet on its bar. I offered to interest the citizens of New Orleans in such pecuniary profits as I might realize by success. The lan proposed had been subjected to one of the most thorough discussions, and as sustained by the opinions of the very ablest engineers in the world. A ery few enterprising citizens here aided me with their means, and with this id and that supplied by myself and parties in St. Louis and New York, we ave been at work less than eleven months, spending our own money, creating o interruption to the old channels of the river, and in that time we have btained *a permanent* increase in the depth on the South Pass bar, which is teadily improving, and which is to-day only one foot less than the dredged-out roove at the Southwest Pass; and yet one would suppose from the fault-finding hat we were increasing the expenses of the government, or wasting the money f all these grumblers. Whereas I have yet to hear one word of doubt or omplaint from the genuine public-spirited men who are spending their own oney under my direction in this important work, and the noble-hearted ones ho are giving it a moral encouragement scarcely less potent and important.

I had not closed the reading of your editorial when I was handed the ccompanying telegram from the jetties. As it is the very latest intelli-ence, it may possess some interest to the public. I will merely add that average flood tide," referred to in dispatch, is about six inches below the evel of the recent tides in the Gulf of Mexico.

Very truly, etc., JAS. B. EADS.

PORT EADS, May 3, 1876—6:15 P. M.

Capt. Jas. B. Eads:—From soundings taken this afternoon, I find seven-een (17) feet over the bar at average flood tide, with channel above deepening t every point.

E. L. CORTHELL,
Chief Assistant Engineer.

APPENDIX IX.

(See page 127.)

ESTIMATE OF THE DETAILED COST OF CONSTRUCTION OF DAM No. I.—HEAD OF THE PASS.

Piling, two main rows, per lineal foot of piles driven	$0.14¼
" " " " " " " " dike	.60
" " " " with bracing, per lineal foot of dike	1.53
Mattresses, foundation, per cord sunken	5.48
" tilted " " in place	4.71
" foundation and tilted, per lineal foot of dike	4.38
Cost per lineal foot of dike	5.91

NOTE.—General expense account does not enter into the above estimate; it includes simply materials actually used and labor performed by boats and men.

APPENDIX X.

(See page 142.)

REPORT OF A COMMISSION

CONSISTING OF J. G. BARNARD, COL. OF ENGINEERS AND BREVET MAJ.-GEN. U. S. A.; H. G. WRIGHT, LT.-COL. OF ENGINEERS AND BREVET MAJ.-GEN. U. S. A.; B. S. ALEXANDER, LT.-COL. OF ENGINEERS AND BREVET BRIG.-GEN. U. S. A.,

UPON THE WORKS FOR THE

IMPROVEMENT OF THE SOUTH PASS

OF THE

MISSISSIPPI RIVER.

[Special Orders No. 229.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
WASHINGTON, *November* 2, 1876.

[Extract.]

1. By direction of the President of the United States, a commission, to consist of the following-named officers of the Corps of Engineers, is hereby appointed to meet in New York city on November 6, 1876, or as soon thereafter as practicable, to report for the information of the Secretary of War an opinion upon certain subjects connected with the improvement of the South Pass of the Mississippi River.

Detail for the Commission.—Col. John G. Barnard, Lieut.-Col. H. G. Wright, Lieut.-Col. B. S. Alexander.

The commission will be governed by instructions to be communicated by the Secretary of War.

* * * * * * * * *

By command of Gen. Sherman:

E. D. TOWNSEND,
Adjt.-Gen.

Official:

L. H. PELOUZE,
Asst. Adjt.-Gen.

WAR DEPARTMENT,
WASHINGTON, D. C., *November* 2, 1876.

GENTLEMEN:—I present herewith for your guidance, the instructions referred to in the inclosed special order.

The purpose in assembling your commission is not to interfere in any way with the duties of Maj. C. B. Comstock, the officer of Engineers, who has faithfully performed the duties assigned to him under the act, viz., "to report the depth of water and width of channel secured and maintained from time to time in said channel, together with such other information as the Secretary of War may direct," but to obtain your professional advice upon certain points which the law requires the Secretary of War to decide upon.

The questions upon which I desire your opinion are as follows:

First.—Is the shoal at the head of the South Pass a part of that pass, or of the main Mississippi River?

If Mr. Eads obtains a channel twenty feet in depth in the South Pass, exclusive of this shoal, is he entitled under the law to his first payment of half a million dollars?

Second.—What depth and width of channel is it desirable to secure permanently through this shoal?

Third.—What is your interpretation of the words "average flood-tide," as used in the second section of the act?

It appears from the records that on the 18th May, 1875, Maj. Comstock propounded this same inquiry to the Chief of Engineers (copy of his letter herewith), and that that officer decided, and the Secretary of War approved his decision, that "the average flood-tide should be determined by excluding the effects of variations in the river's discharge."

Mr. Eads now appeals to have this decision set aside for the reason that "average flood-tide cannot be determined at the head of the pass, if any of the natural conditions affecting that level are disregarded." * * * "Neither the mean effect of the winds nor the mean effect of the rise and fall of the river can be ignored in determining the plane of mean or average flood-tide even at the mouth of the pass, nor can either one be disregarded in fixing the plane of 'average flood-tide' at the head of the pass."

In this connection you will please examine the United States Engineer's gauge, and recommend what point upon it should indicate the plane of "average flood-tide" or zero of reference for all measurements of depth.

Fourth.—I desire a full expression of your opinion as to "the materials used, and the character and permanency with which the jetties are being constructed," and as to whether the work is being constructed according to the spirit of the act, as mentioned in the tenth section thereof.

Fifth.—I should be glad to receive any general suggestions, in connection with this very important work, which you think will assist me in performing the duties required of the Secretary of War by this act.

In order to assist you in forming your opinion, you are authorized to visit the works at the South Pass, and to proceed to this city, if you consider it necessary to consult any records here.

The sum of two thousand dollars will be placed to your credit from the appropriation for contingencies of the Army, and it is hoped that your expenses may be kept within that sum.

A copy of these instructions has been sent to Maj. Comstock, and he has been directed to afford you every facility in his power to aid you in your investigations.

Mr. Eads has also been notified of your appointment, and has been informed that you will be ready to receive any communications he may wish to submit to you.

The unpublished records on this subject are now in my office, and will be open to your inspection, or copies will be sent to you, if desired.

The printed documents you are probably familiar with, including the three reports by Maj. Comstock upon the progress of the works. The fourth report of that officer, dated September 20, and giving the depth of water on August 17, is now in the hands of the printer, and will be forwarded to you as soon as received.

Maj. Comstock has also been requested to make another survey during the present month.

I desire that your investigations be prosecuted with the utmost dispatch consistent with their great importance.

If it is feasible to send me your report, or a summary of its conclusions, in time to be incorporated in my annual report on November 20, I particularly request that you will do so.

Very respectfully, your obedient servant,

J. D. CAMERON,
Secretary of War.

COL. JOHN G. BARNARD,
Corps of Engineers.
LIEUT.-COL. H. G. WRIGHT,
Corps of Engineers.
LIEUT.-COL. B. S. ALEXANDER,
Corps of Engineers.

REPORT.

NEW ORLEANS, LA., *November* 19, 1876.

SIR :—The commission appointed by virtue of Special Orders No. 229, dated Headquarters of the Army, Adjutant-General's Office, Washington, November 2, 1876, has the honor to report, that its members assembled on the 6th day of November, in New York, and organized. Your letter of instructions, dated War Department, Washington, November 2, was received and considered, and on the evening of the 7th the officers of the commission started by railway for New Orleans, arriving there on the afternoon of the 10th; Maj. C. B. Comstock, United States Engineers, the officer appointed according to the act of Congress "to report the depth of water and width of channel secured and maintained from time to time," joining them at Cincinnati. At New Orleans they met Mr. James B. Eads, and at a preliminary meeting in the evening of the 10th, listened to suggestions he had to make; and on the following day examined the maps of recent surveys of works at the South Pass, which were exhibited to them in his New Orleans office. On the 12th, they pro-

ceeded by the revenue cutter *Dix*, which had been placed at their disposal for the performance of their duties, to Port Eads, South Pass. The four following days, viz., the 13th, 14th, 15th, and 16th, were devoted to examining the works at the sea entrance to the South Pass, at the head of the pass, and at Grand Bayou; likewise the plans of the works and the surveys showing their present condition, laid before them by Maj. Comstock, and also by the engineers employed by Mr. Eads, and to discussions; during which Mr. Eads and his assistants, as well as Maj. Comstock, were invited freely to impart information and to present their views.

After mature consideration of the information thus obtained, they now have the honor to report, in response to the five queries propounded to them in your letter of instructions, as follows:

QUERY 1. "Is the shoal at the head of the South Pass a part of that pass, or of the main Mississippi River?"

"If Mr. Eads obtains a channel twenty feet in depth in the South Pass, exclusive of this shoal, is he entitled under the law to his first payment of half a million dollars?"

In answer to the first paragraph of the foregoing, we would say that this shoal is not exclusively a part of the South Pass, for it extends entirely across the river from shore to shore. It is therefore a shoal common to all three of the passes; but the channel (or channels) through this shoal, by which access has been had or is to be had in future from the river above into the South Pass, is a part of that pass. This construction we believe to be in harmony with the views of the commission of 1874, which estimated the total length of the "South Pass" at 12.9 miles, thus embracing the entire distance from the deep water in the river above to deep water in the gulf.

To the second paragraph of this query we answer, Yes; provided the depth so obtained has a bottom width required by the fifth section of the act of Congress.

The obligation of the United States to pay half a million of dollars on obtaining a channel twenty feet in depth, and of not less than two hundred feet in width, is expressed in that section, in terms which apply exclusively to the "wide and deep channel between the South Pass of the Mississippi River and the Gulf of Mexico." The obligations of Mr. Eads in reference to the shoal at the head of the pass are expressed in the second proviso to section 4 of the act, the language of which provides all necessary guaranties, and is the only language of the law defining depths, etc., which does apply to this shoal.

QUERY 2. "What depth and width of channel is it desirable to secure permanently through this shoal?"

The second proviso to section 4 of the act demands a navigable depth "through said pass," and of course through this shoal, of "twenty feet" within thirty months; and "an additional depth of not less than two feet during each succeeding year thereafter, until twenty-six feet shall have been secured." We deem these depths to be satisfactory; and, considering that an inland channel requires less depth for equal facility of navigation than a sea-exposed bar, that they are fairly equivalent to the greater depths demanded by the act in its fifth section for the "wide and deep channel connecting the pass with the Gulf of Mexico."

With regard to the width of channel through this shoal, it is probable that all the necessities of commerce would be satisfied, at least for a time, by a width sufficient for the passage of a single vessel. One hundred feet would suffice for this purpose. We deem it desirable to provide ultimately a channel wide enough for two large ships to pass each other when under full headway, without danger of collision. This would require a bottom-width of, say, two hundred feet. Though this is somewhat greater than is now to be found in reaches of considerable length in the body of the South Pass itself, below Grand Bayou, we recommend it as a desirable width to be secured.

QUERY 3. "What is your interpretation of the words 'average flood-tide' as used in the second (fifth) section of the act?"

The phrase "average flood-tide" is used in the section referred to only in reference to the depths prescribed in that section, which depths refer exclusively to the "wide and deep channel between the South Pass of the Mississippi River and the Gulf of Mexico," *i.e.*, to the channel to be created by "jetties and auxiliary works" through the sea-bar of the South Pass. The expression does not apply to the "navigable depth" to be secured "through the pass" in the second proviso of the fourth section of the act; and hence not to the depth to be secured through the shoal at the "head of the pass." The matter is left, as is the width, to be governed by the general prescription of providing a "navigable depth." This navigable depth ought to be found at the low as well as at the high stages of the river. We therefore consider the principle governing the decision of the Chief of Engineers in his indorsement on the letter of Maj. Comstock, communicated to us with your letter of instructions, to be the correct one for the head of the pass, viz.: that the measure of depths prescribed by the second proviso to the fourth section of the act should be from the level of average high tides "occurring during the stage of the river when the volume is least;" that is, the mean of the high waters of the river at this place, taken for one or more lunations when the river is at what is known as its low stage. Inasmuch, however, as Maj. Comstock found it necessary to fix provisionally his zero on insufficient data, it is recommended that it be revised on the principle above stated.

In reference to the prescriptions of the second (fifth) section of the act, the phrase "average flood-tide" has been universally accepted to mean average high water of the tide; and, with no qualifications in the language, we understand this to mean the average of all daily observed high waters throughout the full cycle of a year. No complaint has been made as to the zero mark fixed by the engineer officer for the determination of the depths of water at the gulf end of the pass. It is possible that, having been established on a series of only three lunations from August 19th to November 9th, it may vary slightly from what would be given by such a protracted series of observations. It is, however, our opinion that this zero, as established, is so nearly correct, that it need not be altered, for alteration would involve confusion in the comparison of future soundings with those heretofore made.

QUERY 4. "I desire a full expression of your opinion as to 'the materials used and the character and permanency with which the jetties are being constructed,' and as to whether the work is being constructed according to the spirit of the act, as mentioned in the tenth section thereof."

The several reports of Major Comstock, the United States engineer officer,

give a very precise description of the materials used. Maps No. 2 of his reports of June 9, 1876 (since printed as Ex. Doc. No. 77, Senate, Forty-fourth Congress, first session), and of his fourth report of September 20, 1876, represent to the eye so clearly the section profiles, the component parts, the dimensions, and manner of construction of the two jetties, that we need add nothing descriptively. Our opinion thereon is expressed as follows:

The commission of engineers of 1874 gave the project for these works a protracted study, and set forth a plan and details, with estimates founded thereon. While Mr. Eads is, by the language of the act, "untrammeled in the exercise of his judgment and skill in the location, design, and construction of said jetties and auxiliary works," yet he is required by the law to construct "thoroughly substantial and permanent works, by which said channel may be maintained for all time after their completion." We find that in general plan the jetties of Mr. Eads correspond substantially with those designed by the board. The materials to be used, as recommended by the board, were, after methods long employed in Holland, to be of layers of mattresses, of willows or other suitable twigs or saplings, placed in layers, with intervening layers of quarry-stone. Still this design was in no respect obligatory upon Mr. Eads, nor should it have been upon an engineer officer of the United States charged to execute this work. With no experience in this country in the execution of such a work, in such a locality, and on this scale, it was impossible to foresee exactly what the work should be. The board expressly states that "it is of opinion that experience in construction may very probably show that the cross section of the dikes may be reduced, thus lessening the cost." It was also an opinion of the board and other engineers that the methods of Holland would undergo material modification in their actual application in this country, and that experience in the work on the locality would also show the cheapest and best methods. Mr. Eads has modified very materially the Holland model of mattresses, and the mattresses he has used are doubtless much inferior to those of the Dutch. Again, the amount of stone thus far used has been very small indeed, barely enough to sink the mattresses. Nevertheless, the jetties so constructed, except at their ends in deep water, where some damage has been done, have resisted, without material injury, the floods, storms, and waves, and there has been more than a year's exposure, with its winter and autumnal storms, for some portions of the existing work.

We do not conceive it to be required of Mr. Eads that each stage of the progress shall exhibit such "substantial and permanent work" as the law ultimately contemplates, but rather that each stage of the work shall show an adequacy to create a channel of the depth and width demanded, and at the same time such a fair and honest prosecution of the work as shall be, as far as it has gone, so much really accomplished toward the construction of works which, in the language of the law, "may be maintained for all time after their completion."

While we believe that engineer officers, applying moneys appropriated to meet their estimates by Congress, would have executed the work differently, especially in applying freely stone to each layer of mattresses, we are nevertheless of opinion that the work is being constructed essentially according to "the spirit of the act as mentioned in the tenth (thirteenth) section thereof."

We would add that the greatest variation from the sectional designs of the

oard of 1874 for the jetties, is to be found on their sea sides. That board ecommended that the jetties should have on their sea sides the same slopes as n the river or channel side. As actually built upon the foundation mattresses, the sea sides are vertical. This construction appears to answer every purose throughout most of the length, for the wide shoals on each side afford reat protection, and there is, as had been expected, a great accumulation f river-sediment and wave-deposit against the exterior of the jetties, by which that protection is augmented.

The outer ends of the two jetties, and especially the end of the eastern one, extend beyond their protection, and are greatly exposed ; and we deem an enlargement of section and a large application of stone to be essential to security.

QUERY 5. "I should be glad to receive any general suggestions in connection with this very important work, which you think will assist me in performing the duties required of the Secretary of War by this act."

The more important of the duties imposed upon the Secretary of War by the act are embraced in the thirteenth section; and of these, the only one on which we have any suggestions to offer is that which requires him to see that the works shall be of such substantial and permanent character as shall maintain the channel for all time after their completion.

We have already remarked that we deem not only an enlargement of section, but a large application of stone to be essential to the security of the jetties, their sea ends especially, and we are of the opinion that this enlargement of section at the sea ends and consolidation throughout by the application of stone should be undertaken at once, and a reasonable progress therein be made the condition of the second and all future payments. The immediate and full consolidation of the jetties should be neither required nor expected, as they will continue to settle for some time, both by subsidence of the bottom upon which they rest, and by the compression of the mattresses of which they are largely composed. But this settlement and consolidation should be hastened, as has just been remarked, by the application of stone from time to time, so that they may be in condition to receive their final finish as soon, at least, as the expected full depth of water in the channel has been obtained.

The present works at the head of the pass are mostly of a tentative and temporary character, and as their proper positions are determined, should be replaced by substantial and permanent structures, to be completed before final payments are made.

Respectfully submitted,

J. G. BARNARD,
Col. of Eng. and Bvt. Maj.-Genl.
H. G. WRIGHT,
Lt.-Col. of Engrs., Bvt. Maj.-Genl.
B. S. ALEXANDER,
Lt.-Col. Engrs., Bvt. Brig.-Gen., U. S. A.

Hon. J. D. CAMERON,
Secretary of War, Washington, D. C.

APPENDIX XL

(See page 107.)

LETTER FROM JAMES B. EADS TO THE SECRETARY OF WAR.

NEW ORLEANS, *April* 19, 1877.

HON. GEORGE W. M'CRARY, *Secretary of War, Washington, D. C.:*

SIR:—On 7th of February, 1877, I addressed a letter to Hon. J. D. Cameron, Secretary of War, requesting that Capt. Brown, U. S. Engineer, assistant of Gen. Comstock, stationed here, be instructed to furnish me or my chief assistant engineer at the jetties the results of his soundings and current observations in the channel through South Pass. I said that permission for one of my assistant engineers to copy his charts would be sufficient for my purpose, and would thus avoid any possible increase of expense in his office.

This letter was written because my chief assistant had been refused a copy of a survey of the shoal at the head of the pass, just completed by Capt. Brown, and which I desired him to obtain and send to me in Washington. Nearly a year ago (23d May, 1876), I requested of the Hon. Alonzo Taft, Secretary of War, "that instructions be issued to the inspecting officer * * to promptly supply me with any official information he may from time to time acquire respecting these works and their results, which I may deem important to facilitate us in carrying out the intent of the grant, or in protecting us from mis-representation. In compliance with this request the Secretary addressed Gen. Comstock letters, dated 28th June and 31st July, 1876, which directed him to forward me a duplicate copy of his official reports simultaneously with the transmission of the originals to him, and to furnish me "the results of actual soundings that have been or may be hereafter made under (his) direction, in connection with this improvement." In compliance therewith instructions were given, I believe, by Gen. Comstock to Capt. Brown, to permit me and my assistants to *look* at the results of his soundings, but not to permit me to take any copies of them without first referring them to him at Detroit.

It is scarcely necessary for me to point out the importance of having the earliest official information respecting any changes which are produced by my works; and I respectfully submit that there can be no injury to the public by furnishing me promptly any such information as soon as it is obtained by Capt. Brown.

I do not ask that he should make surveys or observations, or perform any work for my benefit or information; but as these are contemplated by the law, and are made for your information, and for the benefit of the public, I cannot

conceive how it is possible that the public interest can suffer, or the dignity of the Secretary of War be lessened, by permitting me to know, at the earliest moment, whatever facts are developed by these surveys, that have relation to the success of the improvement.

Until the instructions of June and July referred to were issued to the inspecting officer, the results of the surveys of his assistant were carefully kept secret from me and my employees; and it was not until after they were transmitted by Capt. Brown to Gen. Comstock at Detroit; and by him to the Chief of Engineers; and by him to the Secretary of War; and by him to Congress; and by Congress to the public printer; and by him back to Congress, that they were seen by the public or myself. They were then so old as to be of little interest or value to any one.

Although the instructions of the Secretary of War were evidently intended to give me the benefit of this information at the earliest moment, I cannot at present have a tracing from Capt. Brown's official surveys made, even at my own expense, until it is sent to Detroit for examination or approval. The location of an inspecting officer on the northern lakes for works of such importance at the mouth of the Mississippi, and the difficulty of obtaining a statement of the simplest facts from him with promptitude, is an injustice to me and my associates, and an injury to the public.

The depth and width of channel between the jetties last October entitled me to the first payment of $500,000 on account of this work. The Secretary of War ordered Gen. Comstock to come to Washington for the purpose of consulting him with reference to my obligations respecting the shoal in the Mississippi River at the head of the Pass. Gen. Comstock was emphatic in the opinion that I was not entitled to the payment, because I had not an equal width and depth through this shoal. I appealed from this decision, and the question was referred by the Secretary of War to a commission of officers of higher rank, viz.: Generals Barnard, Wright, and Alexander. They decided that I was entitled to this payment whenever the requisite width and depth were secured through the jetties, without reference to the depth on the shoal; the depth through the latter being insured by my liability to have the grant forfeited. This opinion was then submitted to the Attorney-General, who emphatically sustained it, thus proving that General Comstock was wrong. The result, however, caused me to be delayed several months in receiving the payment to which I was entitled in October; and it was not until about the middle of February that I received it.

After suffering the hardship of delay in payment, resulting from the inspecting officer misrepresenting the law, and awaiting its reversal by the late Commission and the Attorney-General, I was put to a further delay in payment; because, although this survey, like all others made since Capt. Brown was stationed here in December, 1875, was not made under the formal supervision of the inspecting officer, yet it had to go to Detroit for examination and approval by him; and then, after the chart reached there, some informality in its certification at the jetties necessitated a further delay, until a duplicate could be sent from the mouth of the Mississippi to Detroit; after which the report entitling me to payment was finally sent by the inspecting officer to the Secretary of War.

Within the last week I have found it necessary to provide an additional

amount of money to carry on these works; and I submitted the terms of a loan for two hundred thousand dollars to capitalists in this city, who had previously supplied a portion of the money expended on them. A meeting of these gentlemen was called a few days ago, at which the loan was proposed. The next morning the Associated Press dispatches contained a synopsis of Gen. Comstock's report of 5th April to you, in which it is stated that the twenty-foot channel through the jetties has been reduced from two hundred feet to seventy feet in width. The effect of this upon the loan you can readily understand.

The report just made to you, dated 5th April, 1877, gives the result of soundings made a month previously; but it gives neither to you nor to the public any information as to the present condition of the channel. A subsequent survey or reconnoisance made by Capt. Brown, I am verbally informed by him, within the last ten days, shows a twenty-foot channel with a least width of three hundred feet; yet Capt. Brown dare not certify this improvement to me, because he has no authority or permission from Detroit to do so.

The delay in getting my first payment prevented me from completing and strengthening the sea ends of the jetties to resist the storms of winter; and I have been compelled to rebuild a large amount of the work, the destruction of which caused the deterioration of channel referred to by Gen. Comstock. Their improved condition has now again enlarged the channel; but before I can get the official evidence of it, its certification will be of no value to me.

Last May, when semi-official misrepresentations were published by Capt. Howell respecting the depth of channel we had then secured through the jetties, I asked the Secretary of War, by telegraph (see my letter, 23d May, 1876), to direct Gen. Comstock, who was then on the spot, to measure the depth between the jetties, and certify the same, so that I could correct this misrepresentation, which was then seriously embarrassing our enterprise by destroying the confidence of the public and the faith of capitalists in it. This could have been done in three hours; but the request was refused; and nothing but the passage of the Cromwell steamers through the jetties, a few days afterwards, furnished to the public the evidence that Capt. Howell had officially published a deliberate and gross misstatement of the depth of the jetty channel. In connection with this misstatement, the same officer, at the same time, published a statement to the effect that, from his own surveys, he knew that a bar was forming one thousand feet in advance of the jetties, and that a shoal had made out three hundred and eighty feet from the west jetty towards this bar. This statement *was absolutely untrue*. It was designed to impress the public with the belief that these works would prove a failure, as the rapid reformation of the bar in advance of the jetties, predicted by the chief of engineers, was actually progressing; whereas, I knew from my own surveys, and from soundings just then made by the United States Coast Survey in front of the jetties, that the very reverse of his statement was the fact. An immediate official disproof of Capt. Howell's statement regarding the depth of channel being denied me (see Mr. Secretary Taft's telegram in my letter of 23d May), I appealed, by telegraph, to the Superintendent of the Coast Survey to instruct Mr. Marindin to certify to me the results of the survey he had just made, and to make which survey *I had furnished a steamer*. His refusal will be found in my letter of 23d May. I was, however, determined to have this

official disproof if possible, and therefore requested the Secretary of War to obtain it. On the 19th of July, he requested the superintendent to furnish the *War Department* with a comparative chart of the soundings made May, 1875, and May, 1876, in front of the jetties. The verbal declaration after receipt of this request, made to me by the superintendent, that *he would not* supply this information even to the War Department, caused me to appeal by letter a few days afterwards to Mr. Secretary Morrill, of the Treasury, to instruct the superintendent to furnish the chart to me, with an official statement of the results shown by it. Mr. Morrill, on 26th July, refused this request, on the plea that the last survey was "unauthorized and informal;" "while provision is made in the said [jetty] act for the facts and information desired through the War Department."

Being thus foiled in getting the official disproof of this misrepresentation of Capt. Howell, I finally appealed to the House of Representatives; and a resolution, directing the Secretary of the Treasury to furnish the House the specific information asked for by me, was unanimously passed by that body, immediately after the Secretary of the Treasury refused to give it to me. In pursuance of this resolution, the House and the War Department were supplied 1st August with the information solicited a fortnight previously by the Secretary of War; and it proved that, instead of a reformation of the bar, sixty-eight thousand four hundred cubic yards of material had actually been scoured away, in a space of two thousand one hundred feet square, immediately in front of the jetties, in excess of all deposits made on that area.

I refer to these facts regretfully, and only to show you that when official information would be of value to me, or even when absolutely necessary to right a gross wrong by a government officer, it has been almost impossible for me to get it. Although the fact was shown by two surveys, and the report of the Superintendent of the Coast Survey last August, that the predicted bar advance had not occurred, but that the water last May was actually deeper immediately in advance of the jetties than when they were commenced; and although this fact would greatly increase the confidence of the public in the permanency of this improvement; and although it constitutes a most interesting fact in the history of the work, it has not yet elicited the notice of the inspecting officer in his reports to you. Every temporary *advance* in the contour curves of the bar, however, observed during the rapid scour between the jetties previously, was reported by him, but his reports have never alluded to the fact that a decided recession of the outer face of the bar has occurred since the construction of the jetties.

I earnestly beg that, in connection with these representations, you will kindly consider the fact that we are executing a great national work, almost wholly without aid of the government—for thus far we have received less than one-tenth part of the price to be paid for it—while we have already secured much deeper water than ever existed at the mouth of the river before; and which now constitutes a safe channel, in no place less than twenty and one-half feet deep, at average high tide, from New Orleans to the gulf, where there was previously scarcely eight feet in depth. Our works and our good faith surely entitle us to such aid as the government can give us without injury to the public interest, and also to such moral support as can be rendered by furnishing promptly, in an official form, any certification that may be desired respecting

the results accomplished. The law constitutes you the agent of the United States to carry into effect the provisions of the act, and your practical knowledge will certainly plead my excuse for appealing to you most earnestly to correct the injustice we are suffering, more especially as it has been continued so long after a correction has been solicited. If you will kindly consider that this work is not only the largest, in point of cost, which the United States is executing, but that it far surpasses, in the importance of its results, all others in this country, you will, I am sure, pardon me for trespassing upon your time with a letter of this length.

In conclusion, I respectfully beg:

1st. That the inspecting officer of these works be located at New Orleans, or at the jetties; and,

2d. That he be authorized to publish promptly, from time to time, the depth and width of channel through South Pass; and,

3d. That he be directed to furnish me or my principal assistant engineer, officially and promptly, such information respecting the changes in the channel throughout the pass, the jetties, and the outer slope of the bar, and such other results of the works in progress as he and his assistants shall obtain from time to time, by their surveys and observations.

I have the honor to be, your obedient servant,

JAS. B. EADS.

APPENDIX XII.

(See page 168.)

LETTER FROM THE SECRETARY OF WAR,

SUBMITTING A STATEMENT FROM JAMES B. EADS RELATIVE TO WORK EXECUTED AT THE SOUTH PASS OF THE MISSISSIPPI RIVER.

MAY 14, 1878.—Referred to the Select Committee on Transportation Routes to the Seaboard, and ordered to be printed.

WAR DEPARTMENT,
WASHINGTON CITY, *May* 14, 1878.

The Secretary of War has the honor to transmit to the United States Senate a copy of a communication from James B. Eads, dated the 7th instant, submitting a statement relative to the amount of work executed at the South Pass of the Mississippi River, and asking that certain specified modifications be made in the conditions imposed by the law known as the jetty act, under which the works at the South Pass have been prosecuted.

This communication was referred to Gens. J. G. Barnard and H. G. Wright, of the Corps of Engineers, for examination and report, and a copy of their report, dated the 13th instant, is herewith transmitted.

It will be seen that while the Board are of the opinion that the widths of channel proposed by the petitioner may be considered as fairly meeting the present wants of commerce, they regard the question whether the concessions asked for should be granted as peculiarly a question for Congress to decide.

The views expressed by Gens. Barnard and Wright are concurred in by this department.

GEO. W. MCCRARY,
Secretary of War.

The PRESIDENT,
United States Senate.

WASHINGTON, D. C., *May* 7, 1878.

SIR:—I have reached a point in the construction of the works authorized by the jetty act at which I deem it absolutely necessary to communicate certain matters for your consideration. I respectfully submit, therefore, the reasons which induce me to ask for such modifications in the times of payment set forth in the law as are necessary to relieve me and my associates of the

serious financial difficulties with which we are embarrassed, and to enable us to prosecute the work with greater energy.

The progress of the work has shown that the desire to guard the government against the possibility of bearing any portion of the risk of the jetty system, or of the hazards of construction, has resulted in framing a law which imposes on us unnecessarily stringent conditions of payment. In consequence of the very large portion of the work which we have had to execute in order to secure the two payments already received, and of the stringency of these conditions, we find ourselves oppressed with such a burden of debt as to almost completely paralyze, for the present, our ability to push the work with the energy necessary to insure the largest benefits to the public at the earliest possible time.

The provisions of the law were intended to afford a reasonable reimbursement of our outlays as fast as the work progressed, after certain specified depths of channel should be secured by permanent works. It was impossible, however, to tell with any degree of accuracy how much of the whole work would have to be executed before we could be entitled to the first payments under the law, and while the total cost of the improvement will not exceed the original estimates, the proportion of the entire outlay necessarily expended to secure the present depth has greatly exceeded our expectations.

Experience has shown and custom has sanctioned the wisdom of the government paying ninety per cent. of the contract-price for work as it progresses, by which those who undertake it may avoid excessive rates of interest and needless financial burdens, which can result in no benefit to the government.

The compensation fixed in the law for the work we are executing is to be $5,250,000. We have already completed at least eighty per cent. of this entire work, and have received on it thus far only $1,000,000. If we were compensated for ninety per cent. of the work done, we would receive $2,826,000 more than has been paid to us. We do not ask for any such liberality, but refer to this fact to show the hardships under which we are laboring by the terms of the law, and the absolute security with which the government can grant the relief we are compelled to ask.

By the terms of the act, thirty months from its approval were allowed within which to secure a depth of twenty feet, and two feet additional are required to be secured each year thereafter. The act was approved March 3, 1875, and by September 3, 1877, we were required to have a channel of twenty feet, and twenty-two feet by September 3, 1878. These depths have been already secured, and the stipulated compensation received. We have, therefore, by the terms of the law, until September 3, 1879, to secure twenty-four feet, and to September 3, 1880, to secure the twenty-six feet channel. The interests of the public will of course be promoted by the attainment of these depths at an earlier day.

Under the present terms of payment it will be impossible for us to expend upon the work the large additional sums still necessary to secure the maximum channel at the earliest possible period, for the reason that the indebtedness already incurred will absorb so much of the next payments as to leave for it a totally inadequate provision.

The sum of $1,250,000 of the stipulated compensation becomes due and payable after certain depths have been maintained for twelve months, and

these payments bear interest at the rate of five per cent. per annum. By adding these deferred payments to the cash payments as the latter are earned, the government will save interest on the respective amounts, and will greatly relieve us, while an earlier completion of the work will be secured.

The commission of engineers authorized by Congress in 1874, and which reported in favor of applying the jetty system to the South Pass, proposed to secure a channel thirty feet in depth, and the permanent maintenance of only twenty-five feet, without any specified width. The jetty act requires a permanent depth of thirty feet with a least width of three hundred and fifty feet. This great width of thirty feet water will involve a much larger channel than was contemplated by the commission as proper for the size of the pass. Such great width cannot probably be secured without a central depth of channel several feet greater than that recommended by the commission. We do not ask to have the depth of thirty feet lessened, but observation confirms the opinion (which I expressed to the committees when the bill was under consideration), that the width required was injudicious, and might involve injury to the works.

The payments under the present law are as follows:

On securing—			
24 feet deep by 250 feet in width.....	$500,000 ;	cash in one year....	$250,000
26 feet deep by 300 feet in width.....	500,000 ;	cash in one year....	250,000
28 feet deep by 300 feet in width.....	500,000 ;	cash in one year....	250,000
30 feet deep by 350 feet in width.....	500,000 ;	cash in one year....	500,000
Total.....	$2,000,000	Total.....	$1,250,000

The amendments desired are as follows:

On securing a channel through the jetties—	
24 feet deep by a least width of 150 feet.....	$750,000
25 feet deep by a least width of 150 feet.....	750,000
26 feet deep by a least width of 150 feet.....	500,000
27 feet deep by a least width of 100 feet.....	375,000
28 feet deep by a least width of 100 feet.....	375,000
29 feet deep by a least width of 100 feet.....	250,000
30 feet deep by a least width of 100 feet.....	250,000
Total.....	$3,250,000

Provided, that when each of the above depths and widths has been obtained the survey shall also show through the jetties a channel of the following depths and widths, viz.: When twenty-four by one hundred and fifty feet shall have been obtained, there must also be a channel twenty-two feet deep by a width of two hundred feet; when twenty-five by one hundred and fifty feet shall have been obtained. there must also be a channel twenty-two feet deep by two hundred and fifty feet wide; when twenty-six by one hundred and fifty feet shall have been obtained, there must also be a channel twenty-two feet deep by three hundred feet wide; when twenty-seven by one hundred feet shall have been obtained, there must also be a channel twenty-four feet deep by two

hundred feet wide; when twenty-eight by one hundred feet shall have been obtained, there must also be a channel twenty-four feet deep by two hundred and fifty feet wide; when twenty-nine by one hundred feet shall have been obtained, there must also be a channel twenty-four feet deep by two hundred and fifty feet wide; when thirty by one hundred feet shall have been obtained, there must also be a channel twenty-six feet deep by two hundred feet wide.

By the above arrangement, the first payment of $750,000 will not be made until a channel is attained large enough for all practical purposes; and the fact that no further payments are to be made, except as each additional foot in depth is gained, insures every effort to maintain and increase the size of the channel as fully as under the present distribution of payments.

The act provides that after a channel thirty feet deep and three hundred and fifty feet wide is secured, one hundred thousand dollars per annum shall be paid for its maintenance during twenty years. This clause should be amended to apply to the thirty feet channel above described. The one million dollars reserved by the jetty act to be held in the United States Treasury as security for the performance of this part of our obligations will remain undisturbed.

We undertook the construction and maintenance of these works for six hundred and ninety-two thousand one hundred and ten dollars less than the official estimate of the commission upon whose report the act was framed. We also assumed the whole risk of their failure to produce the desired channel, notwithstanding the confident and reiterated predictions made by official and other experts that they would be unsuccessful. We likewise took all the risk of their destruction by storms and treacherous foundations—dangers which were believed by many to be insurmountable. Besides all this, we were not permitted to improve the pass of our choice, with its normal depth of fifteen feet, but were given one only a quarter as large, with a depth of but eight feet. In spite of the natural difficulties which were to be surmounted during a period of unusual financial prostration, we have carried this enterprise to a point where its complete success is acknowledged even by its opponents. We have changed the little pass into a grand channel of commerce, through which the largest shipping that visits the port of New Orleans floats in safety; while every prediction of failure and of reformation of the bar in advance of the jetties is shown by official surveys to have been without foundation.

We ask no increase in the price of the work, nor do we ask to be relieved of the obligation to create a permanent channel thirty feet deep through the jetties, and that shall be fully as wide as the size of the pass will justify. We ask no legislation to retrieve forfeited privileges or lapsed concessions, nor the assumption of any risk of outlay for doubtful benefits. We ask simply that a reasonable portion of moneys actually expended may be repaid to relieve embarrassments resulting from provisions in the law unusually severe and oppressive, and which cannot now be retained without injuriously reacting upon the commercial and industrial interests of the country. We have striven to carry through, by private means and individual hazard, the largest and most important public work ever undertaken by the government; and have forborne, under many discouragements, to ask relief from the stringent conditions of the law until the official reports of the most eminent engineers of the govern-

ment have confirmed the public faith in our complete success; and now that sheer necessity compels us to do so, we only come after the changing tides of commerce attest the substantial benefits already reached, and after the people are assured that private enterprise and courage have promptly secured, at moderate cost, "an open river mouth" for the Mississippi in lieu of the more costly and dilatory method proposed of a canal with locks. And with this record we ask no payments on the work that will not leave in the hands of the government an ample amount of our compensation to insure the entire completion of the jetties.

With great respect, I have the honor to be, your obedient servant,

JAS. B. EADS.

HON. GEORGE W. MCCRARY,
Secretary of War, Washington, D. C.

[Indorsement.]

WAR DEPARTMENT, *May* 8, 1878.

Respectfully referred to Gens. J. G. Barnard and H. G. Wright, Corps of Engineers, for examination and report.

GEO. W. MCCRARY,
Secretary of War.

WASHINGTON, D. C., *May* 13, 1878.

SIR:—We have the honor to acknowledge the reference to us for examination and report of the communication of Mr. James B. Eads, dated the 7th instant, submitting a statement relative to the amount of work executed at the South Pass of the Mississippi River, and asking that certain specified modifications be made in the conditions imposed by the law known as the jetty act, under which the works at the South Pass have been prosecuted, and to present our views thereon as follows:

In his communication Mr. Eads says:

"We have completed eighty per cent. of the entire work. * * *

"If we were compensated for ninety per cent. of the work actually done, we would receive $2,825,000 more than has been paid to us."

Referring to the words of the law, we find it stated that "the intent of this act is not simply to secure the wide and deep channel first above named, but likewise to provide for the construction of thoroughly substantial and permanent works, by which said channel may be maintained for all time after their completion."

There is in these words quoted from the law not only an unmistakable exposition of its intent, but a clear distinction implied between constructions which will "simply secure the wide and deep channel, and the construction of thoroughly substantial and permanent works," etc.

The works as they now are have served their purpose to the extent of the requirements of the law to this date, but the ultimate requirements of the act are thirty feet depth for three hundred and fifty feet width; whereas only the second of the six stages of progress defined by the law has been arrived at: that which gives twenty-two feet depth for two hundred feet width. There is exhibited, however, a progressive increase of width between the twenty-four feet curves to justify, to some extent, the assumption that the actual works are

fulfilling their function of creating additional depths; but we are not of opinion that taking the volume and linear extent *alone* of the works executed as measured that "eighty per cent. of this entire work has been completed." If we look, therefore, to the requirements of the Law a measure, we should hardly feel justified in accepting the achievement of a channel twenty-two feet deep and two hundred feet wide as 80 per cent. of the achievement ultimately required, viz., thirty feet deep and three hundred and fifty wide, even though it could be shown that the respective quantities of masonry lost measuring in cubic yards for the respective channel dimensions were in that ratio.

Or, if we turn from the question of geometric magnitude of works executed to the character of the existing works, we shall find that very much more than twenty per cent. of work, estimated by cost, remains to be done to make them, in the words of the Law, "substantial and permanent works, by which said channel" may be maintained for all time after their completion."

The commission of officers appointed by direction of the President, November 2, 1876, in responding to the categorical query "as to the materials used, and the character and permanency with which the jetties are being constructed, and as to whether the work is being constructed according to the spirit of the act as mentioned in the tenth (10th) section thereof," in reporting affirmatively, prefaced this expression of opinion by the statement:

"We do not conceive it to be required of Mr. Eads that each stage of the progress shall exhibit such 'substantial and permanent work' as the law ultimately contemplates, but rather that each stage of the work shall show an adequacy to create a channel of the depth and width demanded, and at the same time such a fair and honest prosecution of the work as shall be, as far as it goes, so much really accomplished toward the construction of works which in the language of the Law, may be maintained for all time after their completion.

"We have already remarked that we deem not only an enlargement of section but a large application of stone to be essential to the security of the jetties, their seaward ends especially; and we are of the opinion that this enlargement of sections at the sea ends and consolidation throughout by the application of stone should be undertaken at once, and a reasonable progress therein be made the condition of the second and all future payments."

Moreover, the undersigned, as a commission to decide certain points upon the becoming due (December 15, 1877) of the second payment, in responding to the interrogatory, "Are the jetties and auxiliary works constructed or in progress of construction permanent, sufficient, and thoroughly substantial, within the meaning of said act of Congress?" expressed themselves as follows:

"No part of the jetties are as yet entirely completed, and some portions, especially the outer ends, will require extension of width and a large amount of stone before they are brought to that permanent and substantial condition when completed which the act, in our judgment, requires. This additional work, we understand, Mr. Eads and associates propose to do from time to time, as payments are made to them by the United States. * * *

"With regard to the sea-ends, however, a much larger application of stone will still be necessary; but the defect of vertical sea-sides has not yet been remedied, nor has the required enlargement of section, to any great extent, been made. Nevertheless these ends have maintained themselves so as to suffer

only from subsidence of the bottom, compression of the mattresses, and superficial abrasion by storms. It is understood to be Mr. Eads's intention to enlarge and strengthen these sea-ends in accordance with the views above expressed. * * *

"Further observation and longer experience are necessary to a full development of the question involved, *i.e.*, the destruction of the wood of the mattresses by the teredo; but it is believed that when the lateral slopes of stone are fully provided, the penetration of the worm into the interior of the jetties in these salt-water exposed parts will be checked, and that, to the extent to which they may be impaired, the remedy will be found in the increase of the quantity of stone."

While the commission first referred to conceded that the plan of construction devised by the board of 1874, which recommended the jetty system, was "in no respect obligatory upon Mr. Eads," that "experience in the work on the locality would show the cheapest and best methods," yet it "pointed out the fact that while the plans of the board contemplated the jetties to be made up of one-third stone and two-thirds fascines, the amount of stone thus far used has been very small indeed; barely enough to sink the mattresses." Since that date about twenty thousand cubic yards of stone have been applied, mainly to the top surface of the jetties, and, as we are informed by Mr. Eads, about fourteen thousand cubic yards in addition are on hand ready for application or on the way. The total amount, say, thirty-four thousand cubic yards, is still quite insignificant compared with the more than two hundred thousand cubic yards required by the plans of the board of 1874. We are by no means taking the latter estimate as an absolute standard, for we have conceded that experience justifies a considerable decrease of section, and perhaps a diminution of quantity of stone in parts of the work. But experience has not as yet had time to settle all questions. Stone is the costly element in the construction, and, as already remarked, a large amount of this material must yet be applied.

If we turn now to the works at the head of the passes, we find them alluded to by the commission of 1876 as "mostly of a tentative and temporary character, which, as their proper positions are determined, should be replaced by substantial and permanent structures," etc.; a description which without change applies to these works at the present date.

We by no means depreciate the extent or the value of the works as they exist; but we cannot concur in the petitioner's statement to the effect that "we have already completed at least eighty per cent. of this entire work."

We, as members of the Commission of 1876, and as ourselves constituting the Commission of 1877, have expressed our opinion that the work "is being constructed according to the spirit of the act." We believe, moreover, that the work is now so far advanced and the success so far pronounced that it is for the interest of the government and the country not only to have the constructions carried on, but pushed with the utmost possible vigor to such a point at least as shall insure their security and utmost efficiency of action in increasing the capacity of the channel.

The present law fixes times or periods at which specified depths must be attained, as follows: Thirty months are granted for securing twenty feet; but the law (fourth section) says explicitly: "Said Eads and his associates shall, after securing twenty feet of water, secure an additional depth of not less than

two feet during each succeeding year thereafter." This clearly makes the date of the securing of twenty feet depth the initial time-point from which to compute the periods for the subsequent increased depths. Thus December 27, 1876, was this initial date; hence, twenty-two feet was called for by the law December 27, 1877, and twenty-four feet deep is demanded December 27, 1878, instead of September 3, 1879, as the petitioner states the matter.

The foregoing are the main points in the petitioner's letter upon which he supports his plea for a modification of the terms of the law as regards payments. He states these terms, as they affect future payments, in tabular form, as follows:

Third payment on securing 24 feet depth by 250 feet width,	$500,000; one year thereafter....	*$250,000
Fourth payment on securing 26 feet depth by 300 feet width,	500,000; one year thereafter....	*250,000
Fifth payment on securing 28 feet depth by 300 feet width,	500,000; one year thereafter....	*250,000
Sixth payment on securing 30 feet depth by 350 feet width,	500,000; one year thereafter....	*500,000
Totals.....	$2,000,000	*$1,250,000

To a full understanding of the matter of payments as now prescribed, we add, that the first payment of $500,000 on securing twenty feet depth by two hundred feet width, and the second payment of $500,000 on securing twenty-two feet depth by two hundred feet width, became due December 27, 1876, and December 15, 1877, respectively, and have been paid; that $1,000,000 "deemed as having been earned by said Eads and his associates" when the thirty by three hundred and fifty feet channel shall have been obtained (when the sixth payment becomes due), is to be retained as "security" for the future maintenance for a term of years of said channel. We have thus the stated total of $5,250,000. It must be remembered, however, that the items of the last column (marked *), payable each one year after the respective channel-dimensions to which they refer have been secured, though bearing interest from that date, become due only in case "said depth and width shall have been maintained during twelve consecutive months."

In lieu of the foregoing terms of payment and widths and depths of channel prescribed by the law, the petitioner desires that the following be authorized:

Third. On securing a channel through the jetties 24 feet deep by 150 feet wide, provided it shall also be 22 feet deep by 200 feet wide.....	$750,000
Fourth. On securing a channel through the jetties 25 feet deep by 150 feet wide, provided it shall also be 22 feet deep by 250 feet wide.....	750,000
Fifth. On securing a channel through the jetties 26 feet deep by 150 feet wide, provided it shall also be 22 feet deep by 300 feet wide.....	500,000
Carried forward.....	$2,000,000

Brought forward	$2,000,000
Sixth. On securing a channel through the jetties 27 feet deep by 100 feet wide, provided it shall also be 24 feet deep by 200 feet wide	375,000
Seventh. On securing a channel through the jetties 28 feet deep by 100 feet wide, provided it shall also be 24 feet deep by 250 feet wide	375,000
Eighth. On securing a channel through the jetties 29 feet deep by 100 feet wide, provided it shall also be 24 feet deep by 250 feet wide	250,000
Ninth. On securing a channel through the jetties 30 feet deep by 100 feet wide, provided it shall also be 26 feet deep by 200 feet wide	250,000
Total	$3,250,000

Moreover, the act provides that when the thirty by three hundred and fifty feet channel is secured, $100,000 per annum shall be paid, under certain specified conditions, for its maintenance during twenty years. It is asked that this clause be amended so as to apply to the (as desired) modified thirty feet channel; the $1,000,000 to be reserved as security for this maintenance being still retained under unchanged conditions.

On the above, and the arguments presented in support thereof, we now make the following comments:

The petitioner is quite right in saying that—

The commission of engineers authorized by Congress in 1874, and which reported in favor of applying the jetty system to the South Pass, proposed to secure a channel thirty feet in depth, and the permanent maintenance of only twenty-five feet, without any specified width.

In fact that commission (or "board," as styled by the organic law and order) states:

The depth of thirty feet has been chosen, in order that some time may elapse before the bar which will form at the sea-end of the jetties can have less than twenty-five feet at mean low water upon it, that being the minimum depth which it is desired to maintain.

In other words, that board aimed at simply maintaining, under all contingencies, a navigable depth (of unspecified width) at mean low water of twenty-five feet, and to this end it aimed at securing, in the first instance, thirty feet depth, in order that for a long time thereafter, without extension of jetties, there should be not less than twenty-five feet at mean low water. This depth, since the law makes mean *high* water instead of low water the plane of reference, corresponds nearly to twenty-six feet depth under the law. It only differs, therefore, from the conditions of the petitioner's (desired) fifth payment by the latter specifying a width of one hundred and fifty feet. It only differs from the desired ninth (and last) payment in the latter specifying a width of two hundred feet for a depth of twenty-six feet, and a central depth of thirty feet for a width of one hundred feet. The petitioner states:

"The jetty act requires a permanent depth of thirty feet, with a least width of three hundred and fifty feet. This great width of thirty feet water will in-

volve a much larger channel than was contemplated by the commission as proper for the size of the pass. Such width cannot probably be secured without a central depth of channel several feet greater than that recommended by the commission."

He states also that he represented repeatedly to the committee, when the bill was under consideration, that the width required was injudicious, and might involve injury to the work. We remark that in the pass itself there is found, for the greater portion of its length, a greater width of thirty feet depth than three hundred and fifty feet. We have no personal knowledge of the views of the committee in insisting on the above width. They might have believed it important to have a channel width over the bar fully equal to that in the pass itself.

After these quotations and remarks, we proceed to state our views as follows:

The depths and widths specified, as desired by the petitioner, will fulfill measurably the needs of commerce. We find the depth prescribed for his (desired) fifth payment to be about equal to what the Board of 1874 aimed at permanently maintaining, while the thirty feet depth with one hundred feet width of the ninth and ultimate payment would enable the greatest draught ocean-going vessel to enter the pass. A draught of twenty-three feet (and it must be borne in mind that at the mouths of the Mississippi nearly all the depth on the bar can be realized in actual draught) will include probably eighty-five per cent. of the sea-going vessels of the world; while over the bar of New York Harbor twenty-six feet is about the maximum for regular traffic, and twenty-eight feet (and a small fraction) the maximum ever carried over (the case of a war vessel, the Spanish *Numancia* we believe).

The Board of 1874, to which, as the agent expressly constituted to investigate the whole question, and the authority which recommended and planned jetties for the South Pass, states in reference to its choice of passes, "The greater width (of the Southwest Pass) is more favorable to navigation, but in our opinion the South Pass, when improved, will be adequate to the present and prospective wants of commerce."

The petitioner, we think, has no good ground for the complaint that he was not permitted to improve the pass of his choice. The difficulties, we deem, would have been far greater there: at any rate, Congress was fully justified in legislating for the much less costly improvement for a navigation deemed fully adequate.

We find that under the desired modification to get the fifth payment, the contractor must have secured a navigation capacity probably equal to that contemplated for permanent maintenance by the Board of 1874, while he will at this stage of progress be entitled to but $3,000,000 of the $5,250,000 of his ultimate total. As the law now stands, he would be entitled to $2,250,000, including the sum of $250,000 for keeping open the twenty-four feet channel for twelve consecutive months.

We are of the opinion, as before stated, that the widths of channel proposed by the petitioner may be considered as fairly meeting the present wants of commerce, but the widths proposed by the law as it now stands are obviously desirable; and the question whether the large concession asked for in those widths should be granted, and the compensation for the depths between

enty-four and twenty-eight feet increased at the expense of the deeper ones, ms to be one on which we can hardly be considered the proper exponents.

Respectfully submitted,

J. G. BARNARD,
Col. of Engineers, and Brevet Maj.-Gen.
H. G. WRIGHT,
Lieut.-Col. of Engineers, and Brevet Maj.-Gen.

on. GEORGE W. MCCRARY,
Secretary of War, Washington, D. C.

APPENDIX XIII.

(See page 171.)

LETTER OF GEN. A. A. HUMPHREYS, CHIEF OF ENGINEERS, U. S. A.

WASHINGTON, D. C., *May* 1, 1878.

To the Hon. E. W. ROBERTSON,
Chairman Committee on Levees and Improvement of the Mississippi River, House of Representatives:

DEAR SIR :—A bill has been introduced in Congress for the appointment of a commission of five engineers to survey the Mississippi River from St. Louis to the Gulf of Mexico ; prepare plans for the improvement of its navigation and protection of the alluvial region against overflow, and carry on the works for these objects as moneys are appropriated by Congress for them. Provision is made for four of these engineers to be taken from the Corps of Engineers, the fifth to be appointed from civil life, and it is indicated, though not expressly stated, that the engineer from civil life is to be the president of the commission and is to control its decisions, and no project, plan, or estimate of cost is even to be submitted to the Secretary of War or President of the United States unless approved by the president of the commission. Such power as this has never been conferred upon any presiding officer of a board, commission, or court. This project of a commission of survey and construction is brought forward, notwithstanding that a detailed survey under the Engineer Department is already in progress with a view to low water improvement, and to protection against floods, carried on in accordance with the recommendation of the commission organized by act of Congress of June 22, 1874, to devise a plan of protection against overflow, and with the general project for the improvement of the low water navigation of the Mississippi below Cairo, which was submitted by Major Suter of the Engineers, after the reconnoissance made by him of the bars and obstructions to navigation in that section of the river, under appropriations for surveys for routes of cheap transportation to the seaboard.

It is generally understood that the peculiar features of this bill have their origin, first, in the scheme recently proposed by Mr. Eads to deepen the low water channel of the Mississippi River to twenty feet, claiming that by thus improving the low water navigation of the river, its surface will be lowered in floods to the level of the natural banks, and that in this way levees will be

dispensed with; and second, in the statements made in the public press that Mr. Eads has succeeded in the permanent improvement of the South Pass of the Mississippi River by jetties, while the Engineer Department had opposed the use of jetties for that purpose, and maintained that it was not practicable to improve the pass by them.

It may be well to examine into these grounds of action.

First, as the views of the Engineer Department upon the application of jetties to the improvement of the mouth of the Mississippi River. They are to be found in reports to the Engineer Department, as far back as 1852, and in various official documents readily accessible to the public, notably in the Physics and Hydraulics of the Mississippi River, pages 442 to 456, where the manner of delta bar-formation is described in connection with an account of measurements and experiments made at the mouth of the Mississippi, and where it is demonstrated that by the use of jetties the channels at the mouths of the river may be deepened to the full depth of the pass to which they are applied.

This subject is further treated in still more detail in Ex. Doc. 220, House of Representatives, Forty-third Congress, first session, and an estimate of the first cost of applying jetties to deepen the Southwest Pass to twenty-eight feet is given, as well as the first cost of the same for the South Pass, the cost of permanent works for the former being $7,000,000, and for the latter less than $5,000,000. For less permanent works the cost in each case, it is stated, would be one-half the sums named.

The first cost of these works was not the objection to this method of improvement; but the cost of maintaining the channel depths permanently without fluctuation, which could only be certainly effected by the extension of the jetties constantly in the deep water of the sea, formed the objection to their use, and induced a preference for a canal; though the first cost of a canal would materially exceed the first cost of the jetties at either pass, yet the cost of its maintenance would be small, and there would be no variation in the depth at either the river or sea end of the canal.

During the session of Congress that this subject was discussed, bill after bill was introduced into Congress proposing to pay Mr. Eads $10,000,000 for deepening any pass he might select to twenty-eight or thirty feet at flood tide. These bills were referred to the Engineer Department for its views, and were returned with their defects pointed out, showing that they gave no security to the United States for the permanent maintenance of the deep water desired. This class of bills was advocated on the ground that the jetties once built the channel would be deepened, without the assistance of dredging, even, and that the earthy material borne along by the river would be taken so far seaward by the increased velocity of the current produced by the jetties that no bar would be formed in front of the jetties, and no extension of the jetties seaward would be needed.

It was pointed out by the Chief of Engineers that if it were so, then $7,000,000 for the Southwest Pass and not exceeding $5,000,000 for the South Pass, would be the greatest sums that should be paid for the work, and not $10,000,000. None of these bills were enacted into law.

At the succeeding session of Congress a Board of Engineers, organized under an act of Congress, and composed of three officers of the Corps of En-

gineers, one assistant United States Coast Survey, and three civil engineers, recommended the application of jetties to the South Pass as less costly than the building and maintenance of a canal. The application of jetties to the Southwest Pass they reported would be more costly than the canal. Under this recommendation a contract with Mr. Eads was entered into by act of Congress of March 3, 1875, the total sum to be paid him for obtaining through the South Pass a channel depth of thirty feet at mean flood tide being $5,250,000; and for maintaining it twenty years the sum of $100,000 annually —one million to be retained as security. The works of construction were begun late in the year 1875, at which time the depth on the crest of the bar of the South Pass at low tide was about eight feet; at high tide about nine feet.

The river began to rise about the first of January, 1876, and reached its highest point that year at New Orleans in the early part of May, when the Carrollton gauge read 12.7 feet, the average flood reading of the river at that point for 1876 being twelve feet.

The usual flood reading of the river at Carrollton is above fifteen feet. The Jump and Cubitt's Gap crevasse below New Orleans, but above the head of the passes, discharged a large volume of water into the gulf, so that the maximum discharge into the sea through the passes that year did not largely exceed the volume of the river when half way between low and high water stages.

The river at New Orleans went down in August, 1876, fluctuating somewhat until November, when it reached the extreme low stage, remaining in that condition until the latter part of January, 1877, when a brief rise took place which subsided in February, the river being low until the latter part of March, when the flood rise began, its greatest height, attained in May and June, being eleven feet on the Carrollton gauge. The discharge through Cubitt's Gap and the Jump at the high-water stage was about the same as the preceding year, and again we have, during the high-water period of 1877, a volume of discharge into the sea through the passes not largely exceeding one-half the flood volume of the river. The river began to fall in July, and reached the low-water stage by the last of August.

It is to be borne in mind that it is an established fact, ascertained by repeated examination, which no person accustomed to the investigation of physical phenomena can or does question, that when the Mississippi River is in the flood condition, and the rising river gets above nine feet on the Carrollton gauge, there is a broad, thick sheet of earthy matter moving along the bottom of the passes, which is carried over the bar crests and dumped on the outer slope of the bars. This process continues during the flood stage, and constitutes the bar growth. During the low stage of the river the fresh water of the river does not touch the bottom of the passes, nor of the river for some distance above the head of the passes, the lower part of the channel being occupied by salt water, whose chief movements are independent of the fresh-water current. At this low-water period there is an accumulation of soft earthy matter on the bed, and the bar growth does not go on. On the contrary, the waves of the gulf and its salt-water currents modify the new bar growth of the previous flood stage, the crest usually receding, and the depth on it increasing.

It will be perceived from this statement, and that which precedes it, concerning the highest reading of the gauge at Carrollton, and the volume of discharge into the sea through the passes, that during the high-water stage of

the Mississippi in 1876 and 1877 there was comparatively little bar growth at the mouths of the passes in those years.

Before the construction of the jetties, the annual extension into the sea of the bar of the South Pass did not exceed one hundred feet a year.

The construction of the jetties at the South Pass was begun in the fall of 1875. The report and map of Gen. Comstock (the inspecting officer), of the 9th June, 1876, show that its bar had extended seaward four or five hundred feet (soundings early in May), the depth on the bar growth being between twelve and fifteen feet flood tide, and its outer line or crest resting in water that was about forty feet deep in November, 1875.

The next report of Gen. Comstock, September 20, 1876 (soundings between last of July and first half of August), shows the bar growth in about the same position, the average depth on it being from eighteen to twenty feet flood tide.

The next report of Gen. Comstock, December 6, 1876, shows the condition of the work in November, 1876. The depth on the bar growth had increased about two feet.

The next report of Gen. Comstock, April 5, 1877, shows the condition of the work March 16, 1877.* The depth on the east side of the bar had increased.

By the next report, that of Capt. Brown, August 1, 1877, showing the condition of the work July 24, 1877, we find the total extension of the bar up to that date to have been six hundred feet, the depth on the greater part of the bar varying from fifteen to twenty feet flood tide; on the inner eastern side the depth being about twenty-one feet.*

The next report of Capt. Brown, December 23, 1877, was made after a powerful, newly-constructed dredge had been working on the bar seaward of the jetties for a month, by which means the depth on the bar had been increased, and a channel twenty-two feet deep at flood tide and two hundred feet wide had been secured.* This dredge was designed to work on the newly-grown bar seaward of the jetties, where, from exposure to the sea, the ordinary dredge cannot be used to advantage.

The river at New Orleans began to rise about the 1st January, 1878, and during February and March was in condition to cause some bar growth, the Carrollton gauge reading between nine and ten in February, and between ten and eleven in March. Accordingly, we find Capt. Brown reporting on the 4th and 8th March that the channel of twenty-two feet depth at flood-tide was but one hundred and ten feet wide for a portion of its length "over the bar's crest" (through the new bar seaward of the jetties), and on the 3d April reporting that the least width of this channel (on this bar-growth) "between South Pass jetties" and "deeper water in the Gulf of Mexico" was seventy feet. This decrease of the channel width had taken place notwithstanding that the dredging on the bar growth had been going on with the new dredge designed for sea dredging. Capt. Brown's report of the 3d April also states: "At the head of passes a least depth of twenty-one feet at average flood-tide was found on the 18th of March."

It will be noticed that Mr. Eads obtained the channel two hundred feet wide and twenty feet deep *December* 27, 1876; that is, when the river had been in the low-water stage for several months. The channel two hundred feet

* See the maps accompanying these and previous reports.

wide and twenty-two feet deep was obtained *December* 17, 1877, at which time also the river had been in the low-water stage for several months. In fact, these depths were obtained at the end of the low-water stage of the river.

It may be needless to recur again to the results of careful investigation at the mouth of the Mississippi River, one of which is that during the low-water stage of the river there is no bar growth.

Notwithstanding the discharge of the river through the passes in the flood stages of 1876 and 1877 was so much reduced by crevasses that comparatively little bar-forming process at their mouths went on in those years, *yet the facts exhibited by the reports of the officers inspecting the South Pass show that the views expressed by many engineer officers, the Chief of Engineers among them, that a new bar would form at the sea end of the jetties, and that it would extend into the sea more rapidly than the old bar, are correct even during the changes going on under the scouring power of the jetties, aided by dredging between and seaward of them; and it is also evident that the only method of permanently maintaining a deep channel to the sea is to constantly extend the jetties into the sea in advance of the bar. It is evident that this has not been done in the present case, and undoubtedly because of the great difficulty and expense of extending the jetties into the deep water of the sea. It was precisely this objection to the jetty system which the Chief of Engineers and other engineer officers made. This new bar growth beyond the jetties has been formed under the action of the jetties. To make a channel through it, and to endeavor to maintain the channel, dredging has been resorted to, precisely as was done on the Southwest Pass bar, a process which it was designed by Congress to dispense with in entering into a contract for deepening the South Pass channel by the construction of jetties and auxiliary works, for that contract declares its intent to be "not simply to secure the wide and deep channel first above named, but likewise to provide for the construction of thoroughly substantial and permanent works by which said channel may be maintained for all time after their completion."*

THE FOREGOING HISTORICAL SUMMARY SUFFICIENTLY PROVES THAT THE RESULTS ACTUALLY ATTAINED AT THE SOUTH PASS DISPROVE THE VIEWS ADVANCED BY MR. EADS AND CONFIRM THOSE OF THE ENGINEER DEPARTMENT. HENCE ANY CLAIM THAT HE SHOULD BE INTRUSTED WITH THE CONTROL OF THE MISSISSIPPI RIVER, IN SO FAR AS IT RESTS UPON THE RESULTS THUS FAR ACHIEVED BY HIM, HAS NO PROPER BASIS. * * *

Very respectfully,

Your obedient servant,

A. A. HUMPHREYS.

APPENDIX XIV.

(See page 172.)

REVIEW BY JAS. B. EADS

OF THE LETTER OF

GEN. A. A. HUMPHREYS,

Chief of U. S. Engineers, May 1, 1878,

TO

HON. E. W. ROBERTSON,

Chairman House Committee on Levees and Improvement of the Mississippi.

NATIONAL HOTEL,
WASHINGTON, D. C., *June* 1, 1878.

To the Hon. E. W. ROBERTSON,
Chairman Committee on Levees and Improvement of the Mississippi River, House of Representatives:

DEAR SIR:—I have just read with astonishment a letter addressed to you, dated Washington, D. C., May 1, 1878, and signed by A. A. Humphreys. As the writer holds the office of Chief of Engineers, U. S. A., he is in a position to have at hand reliable official facts which emphatically refute many of the statements contained in his letter respecting the jetties at the South Pass. The letter seems ostensibly intended as a protest against the improvement of the Mississippi River being in any wise intrusted to me. He assumes that the bill providing for a commission of five engineers to prepare plans for the improvement of the river is designed to place its whole control in my hands, whereas the only bill reported from your Committee to the House six weeks ago, provides that three of the five engineers shall be taken from the army, and that one of these three shall be president of the commission. So far from my expecting to have the presidency of it, the bill prevents the possibility of such a thing. Nor have I ever expressed to a single member of the Senate or House a wish to have its provisions altered, nor have I authorized or requested any one to secure the presidency of the commission for me.

I shall reserve the discussion of the views entertained by General Humphreys and myself, respecting the improvement of the river, until a more convenient season. It is sufficient to say here that they are totally different. I

cannot, however, permit some of the statements in his letter respecting the jetties to go unchallenged.

General Humphreys says the views of the Engineer Department are to be found in its reports as far back as 1852; "notably in the Physics and Hydraulics of the Mississippi River, pages 442 to 456, * * * where it is demonstrated that, by the use of jetties, the channels at the mouths of the river may be deepened to the full depth of the pass to which they are applied."

It is encouraging to see that General Humphreys desires to be recognized as one of the earliest to suggest jetties for the improvement of the mouth of the Mississippi; and, as the South Pass has a depth through it of thirty feet, this testimony will probably remove from the minds of those who consider him an authority upon the jetty question all doubt as to the ability of the jetties to produce the maximum depth I have undertaken to secure.

General Humphreys, in his letter, refers to the earlier reports on the jetties by General Comstock, to prove that the bar had advanced four or five hundred feet in May, 1876. The answer to this absurdity will be found in a comparative chart of surveys of the outer crest of the bar, made by the United States Coast Survey, in May, 1875, before the jetties were begun, and in May, 1876, accompanied with a statement from the Superintendent of the Coast Survey, Hon. C. P. Patterson. They were furnished, in compliance with a resolution of the House of Representatives, and duplicates were at the same time, August 1, 1876, sent to the War Department. Reference to them will show that, instead of there being an advance of the bar, there had been excavated by the current from a space two thousand one hundred feet square in front of the jetties, sixty-eight thousand four hundred cubic yards of material in excess of deposits made in that area during the year.

General Humphreys says:

"By the next report of Captain Brown, August 1, 1877, showing the condition of the work July 24, 1877, we find the total extension of the bar up to that date to have been six hundred feet. The depth on the greater part of the bar varying from fifteen to twenty feet flood tide; on the inner eastern side the depth being about twenty-one feet." A foot-note says, "See the maps accompanying these and previous reports."

The report of Captain Brown, August 1, 1877, shows no such extension, nor do any of his maps. On the contrary, he says on page 26:

"On sheet No. 4 will be found the results of a survey on June 20 to June 22, 1877, of a mile or more beyond the ends of the jetties, and for a considerable space on either side. A comparison of this chart with that of the survey of June 20 to 24, 1876, reveals the following regarding various curves of equal depth: Averaging, the twenty-feet curve has receded about two hundred feet, the thirty-feet curve about three hundred feet; the forty-feet curve has remained nearly stationary on the whole." * * * * * * * *

The curves referred to indicate the form or contour of the outer slope of the bar between the depths of twenty and forty feet.

By reference to Captain Brown's chart, No. 4, it will be seen that an area of about one square mile in front of the jetties is embraced in this survey, and this has been subdivided by him on the chart into twenty-one sections, the whole forming a fan-shaped area in front of the jetties. A portion of this area—sections No. 1, 7, 13, and 21—lay to the right and left of the end of

the jetties, and out of the track of the river's discharge. Referring to this chart, Captain Brown, on page 28, says :

"Taking into account all the divisions, except 1, 7, 13, and 21, we find that the scour in the year was one million one hundred and forty-five thousand nine hundred and seventy-six cubic yards, equivalent to a scour of 1.3109 feet, or one foot and three and seven-tenths inches, over this latter area."

By a glance at the table on page 30 of the report, it will be seen that section 17, containing about thirty-eight acres, had an average depth of 29.28 feet in 1876, and in 1877 this depth had increased almost four feet, viz., to 33.25 feet.

It is thus shown that General Humphreys' statement is not only directly refuted by Captain Brown's report, to which he refers, but that the bar, during the twelve months, had actually receded two hundred or three hundred feet ; that the bottom for a mile in advance of the jetties had deepened one foot and three-tenths, and that the portion immediately in front of the jetties, thirty-eight acres in extent, and precisely where General Humphreys predicted the reformation of the bar would occur, had actually deepened in one year nearly four feet.

General Humphreys says :

"The next report of Captain Brown, December 23, 1877, was made after a powerful newly-constructed dredge had been working on the bar seaward of the jetties for a month, by which means the depth on the bar had been increased, and a channel twenty-two feet deep at flood tide and two hundred feet wide had been secured."

On page 17 of this report Captain Brown says :

"When the new dredge began its experimental work, the interruption to the twenty-two-feet channel, *i.e.*, from twenty-two feet inside on the bar to twenty-two feet outside, was fifty feet only."

On page 19, he says :

"In obtaining the channel twenty-two feet deep for a width of two hundred feet, the dredge *Bayley* has worked about twenty days, of ten hours each."

Soon after the channel referred to was obtained, entitling me to the second payment of $500,000, the Secretary of War directed a Commission of Engineers, composed of Gens. Barnard and Wright, United States Engineers, to visit the works, and among other subjects they were required to report upon the following interrogatory, viz.:

"Have such depth and width of channel been obtained by the action of such jetties and auxiliary works as are contemplated by the terms of the act of Congress aforesaid ?"

The report of this commission will be found in Ex. Doc. 37, Forty-fifth Congress, Second Session, House of Representatives.

In answering this interrogatory the commission says, on page 5:

"If we look at the actual facts presented by the prosecution of this work, we find that where two and a half years ago there was a bar at the mouth of the South Pass of over two miles in extent, measured from twenty-two feet water inside to the same depth outside, over about half a mile of which there was but eight feet of water, 'a wide and deep channel' of twenty-two feet depth now exists, and a result inferior in physical magnitude, but no less in im-

portance, at the head of the passes has been obtained. And these results are so exclusively due to the jetties and auxiliary works, that the auxiliary aid of 'appliances,' if in such we include dredging machines, is utterly insignificant, consisting mainly, indeed, in a slight widening at two points, and widening and deepening at a third."

Gen. Humphreys says, in italics:

"*Yet the facts exhibited by the reports of the officers inspecting the South Pass show that the views expressed by many engineer officers, the Chief of Engineers among them, that a new bar would form at the sea-end of the jetties, and that it would extend into the sea more rapidly than the old bar, are correct, even during the changes going on under the scouring power of the jetties, aided by dredging between and seaward of them.*"

Gen. Humphreys predicted (see page 677, last edition Physics and Hydraulics) that the bar, under the action of jetties, would advance six hundred and seventy feet annually. Instead of this bar advance, as predicted, there is shown to have been no advance at all, but an actual recession. He, however, proceeds to say:

"*And it is also evident that the only method of permanently maintaining a deep channel to the sea is to constantly extend the jetties into the sea in advance of the bar.* * * * * * *It was precisely this objection to the jetty system which the Chief of Engineers and other engineer officers made.*"

Capt. Brown, on page 26 of his seventh report, August 1, 1877, says:

"It must be noted in regard to the recession of the twenty-feet and thirty-feet curves that the present end of the east jetty is three hundred and thirty feet north of what I have always called the old end of the east jetty, and the present end of the west jetty is two hundred and sixty-three feet northerly of the point formerly considered to be the end of the west jetty."

The meaning of this is that, instead of having to advance the jetties six hundred and seventy feet every year, as predicted, at a cost of $670,000 (see page 677, last edition Physics and Hydraulics), they are actually more than two hundred feet shorter to-day than they were originally intended to be. The deepening has been so marked at the sea-ends of the jetties, where the predicted bar growth was to occur, that I have not found it necessary to complete them as far out as they were located and partly built two years ago.

This notable difference between his declarations and the official reports I have quoted, proves that on the subject of the jetties Gen. Humphreys is not a trustworthy authority.

Gen. Humphreys says:

"*To make a channel through it* [the 'bar growth,' as he calls it], *and to endeavor to maintain the channel, dredging has been resorted to precisely as was done on the Southwest Pass bar, a process which it was designed by Congress to dispense with in entering into a contract for deepening the South Pass channel by the construction of jetties and auxiliary works.*"

The commission, from whose report I have before quoted with reference to dredging, states on page 4:

"If, however, we refer to authoritative statements of the methods of applying that principle, we find it stated in the Physics and Hydraulics [page 489, reprint], in treating of the 'plan of jetties,' that 'the erosive action should be aided at first by dragging and scraping the hard portion of the bar.'"

Having himself pointed out in the Physics and Hydraulics the importance f "dragging and scraping" as an auxiliary of the jetty system, his objection > my use of a dredge at the South Pass is without force. But that it was learly my right to hasten the development of the channel by dredging is hown by the commission to whom this question was referred. It says, page after referring to an item of $250,000 estimated for dredging by the previous ommission of 1874, in connection with the jetties:

"We conceive, therefore, that the true intent of the proviso does not pro- ibit the auxiliary aid of dredging; that its spirit is as above defined, and that, ndeed, in the authorizing of the employment of such boats, rafts, and appli- nces as he may in the 'prosecution of said works deem necessary,' allows redging, and should not prohibit payment for channel widths and depths hich the jetties and auxiliary works have to all intents and purposes really reated, and to which dredging has been slightly auxiliary."

Of the cost of the jetties, Gen. Humphreys says in his letter:

"This subject is further treated in still more detail in Ex. Doc. 220, House Representatives, Forty-third Congress, first session, and an estimate of the rst cost of applying jetties to deepen the Southwest Pass to twenty-eight feet given, as well as the first cost of the same for the South Pass; the cost of ermanent works for the former being $7,000,000, and for the latter less than 5,000,000. For less permanent works the costs in each case, it is stated, ould be one-half the sums named."

Gen. Humphreys evidently intends to create the impression that he showed Congress in 1874 that the jetties could be built for less than the price to be id to me.

In Appendix M, page 677, "Physics and Hydraulics," last edition, the cost applying the jetty system to the Southwest Pass is stated as $23,000,000, and e cost of applying it to South Pass, after adding $670,000 per annum for ex- nsion, and $100,000 per annum for dredging, is thus expressed:

"The total cost to the government of securing permanently a depth of enty-seven feet at low water by this pass will then be about $17,000,000."

Thus, to defeat the jetty bill in 1874, and secure the construction of the ort St. Philip canal, the cost of which is stated on the same page to be but 3,000,000, the official assurance was given that the jetties at South Pass ould cost $17,000,000; and now the same eminent authority who made that atement, wishing to depreciate the value of my works, leads you to believe at he only estimated the cost of jetties in 1874 at less than $5,000,000.

I have shown conclusively, from official reports on the jetties, that there has en no advance of the bar; that it has not been necessary to extend the jetties, d that there has been no shoaling in front of them. These three facts are ecisely the opposite of the results predicted by Gen. Humphreys. It is evident om these extracts, that the conviction which Gen. Humphreys entertained in 74, that the jetty system, if applied to the Mississippi River, would prove a ilure, has become so fixed in his mind that he is unable to realize the em- atic official declarations of the officers of his own corps, which testify to eir complete success.

The act of Congress of March 3, 1875, provided:

"Said Eads shall be untrammeled in the exercise of his judgment and skill the location, design, and construction of said jetties and auxiliary works."

This meant that, having undertaken an important work at the risk of myself and associates, I should have no hostile interference on the part of the government so long as I should faithfully carry on the work. In contempt of this provision of the law, the Chief of Engineers, U. S. A., in the summer of 1875, when I had just begun the jetties, set himself assiduously at work to impeach my judgment and skill, and to show that the enterprise would be a failure. Not only was his time given to this effort to defeat the purpose of Congress, but the public money was used to print his "memorandums" against the South Pass jetties. These were issued in pamphlet form for circulation, to lessen the public confidence in my undertaking. They were then put in his annual report for 1875; and in 1876 they were reproduced with added matter in the last edition of the "Physics and Hydraulics of the Mississippi."

This was not only an injury to me, but was a flagrant disrespect to Congress, whose act had provided that I should be free from such interference.

The fact that Congress, in passing the jetty act, had disregarded the unsound views of General Humphreys, would fairly excuse his loss of temper, but could not justify this reproduction at the public cost of his repudiated theories.

Although the jetty act was purposely framed to exclude General Humphreys from all connection with the work (because of his hostility to it), by providing that the inspecting officer should be detailed to report to the Secretary of War, General Humphreys gave the officer his instructions, and the reports were made to him during the first year, when his interference and hostility became so pronounced that I appealed successfully to the Secretary of War, in an open letter, May 23, 1876, to have him absolutely excluded from any further connection with the work, and to have the inspecting officer report directly to the Secretary of War, as the law provided. And now, on the very day when a measure to secure the more vigorous prosecution of the work is reported to the Senate from the appropriate committee, General Humphreys presents the letter I am reviewing, evidently with the intent to defeat this measure; and as a pretext for presenting it, asserts that a bill has been introduced in Congress to give me the control of the further improvement of the Mississippi River, when he must have known, or could easily have ascertained, that no such bill has been reported by your committee, or any other.

And, in absolute defiance of the plainest official evidence to the contrary, Gen. Humphreys makes the astonishing statement that "*the results actually attained at the South Pass disprove the views of Mr. Eads and confirm those of the Engineer Department;*" while the safety and ease with which the heaviest draught ships already use the jetty channel, and the immense benefits resulting to commerce, should convince even him of the wisdom of the government in rejecting the advice of the Chief of Engineers when deciding on the problem of improving the mouth of the Mississippi River.

Very respectfully,

JAS. B. EADS.

APPENDIX XV.

(See page 177.)

MATE OF THE DETAILED COST OF THE CONSTRUCTION OF THE SILL ACROSS PASS À LOUTRE.

Total number of cords of mattresses.....3230.62.
" " lineal feet of sill.....2950.00.

s of Material or Work.	Total Quantity.	Detailed Cost.	Amount to One Cord Mattress.	Cost per one cord of Mattress Work.	Cost per Lin. Ft. of Sill.
rages.....	20	$57.56		$0.356	$0.39
Piles (rear).....	63–3394 lin. feet.	0.209	1.02	0.219	0.24
" (side).....	84–4364 "	0.221	1.35	0.30	0.327
esses, Material.....	3230.62 cords.	2.578		2.578	2.723
Construction..	" "	.65		0.65	0.711
g and Placing.....				0.706	0.774
.....	908.04 cub. yds.	3.80	0.28	1.059	1.159
g.....				0.413	0.453
intendence and neral Expense acc.				0.479	0.514
Total.....				$6.660	$7.291

Cost per cubic yard.....$1.418.
Cost per cubic yard to Mr. Eads..... 5.360.

APPENDIX XVI.

(See pages 183 and 209.)

FINAL ESTIMATE OF MATERIALS USED ON JETTIES AND AUXILIARY WORKS, JUNE, 1875–JUNE, 1880.

What work.	Willows. Cords.	Stone. Cubic yards.	Concrete. Cubic yards.	Crib timber. Lineal feet.
East Jetty	28,718.03	43,400.36	5,106.00	34,201.
West Jetty	23,812.61	23,429.31	2,220.00	33,549.
Kipp Dam	2,099.53	2,237.32		
Wing dams	8,621.95	2,411.10		
Rubble wall		463.00		
Picayune Bayou	56.00	20.41		
Grand Bayou	3,887.96	1,258.00		
East Dike	7,592.00	2,742.80		
Dam No. I	2,547.86	1,260.00		
Island Dike	11,462.58	3,077.69		
Lighthouse Dike	10,566.21	3,669.35		
Island Dam	2,928.41	1,451.25		
Cross Dike	1,864.19	437.00		
Southwest Pass sill	10,057.94	2,809.36		
Pass à Loutre sill	3,230.62	903.04		
Upper Dam	5,335.07	1,674.43		
Lost and no record	3,896.05	1,255.53		
Total	126,697.01	92,499.95	7,326.00	67,750.

Total amount of all works, 702,973 cubic yards.

APPENDIX XVII.

(See pages 192 and 212.)

OF CHANNEL, EACH 2,000 FEET, FROM REPORT OF CAPT. M. R. BROWN, JUNE 30, 1879.

Date.	Distances in feet from East Point.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
-, 1875	22.5	18.7	16.7	10.2	9.7	9.2
-, 1876	23.3	20.3	22.0	21.0	17.1	15.0
-, 1876	23.5	19.6	21.0	23.5	23.0	19.8
-, 1876	22.0	20.3	21.1	21.2	21.1	20.3
, 1877	24.1	21.1	23.2	22.0	21.2	20.5
, 1877						21.3
, 1877						20.5
), 1877				22.1	21.4	19.5
, 1877						17.8
, 1877						18.0
, 1877	24.9	24.0			23.5	
, 1877				23.8		
, 1877			26.0			
, 1877						20.3
), 1877						20.8
, 1877						20.7
, 1877		24.4				
, 1877						21.0
, 1877	26.3		28.5			
, 1877				24.2		
, 1877						21.3
, 1877					23.0	
, 1877						23.7
, 1878						23.0
, 1878						22.8
, 1878						23.2
, 1878						20.5
, 1878	26.0	25.9				
, 1878			35.5			
, 1878				25.4		
, 1878					24.3	
, 1878						23.0
, 1878						23.2
, 1878						22.3
, 1878						22.2
, 1878						22.0
, 1878						21.9
, 1878	28.4	26.4	35.7			
, 1878				27.1	25.3	

APPENDIX XVII.—(*continued.*)

Date.	Distances in feet from East Point.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 20,000.
Dec. 6, 1878						23.0
Dec. 28, 1878						23.0
Jan. 20, 1879						23.9
Feb. 13, 1879						22.2
Mar. 14, 1879						24.8
Mar. 19, 1879	28.6	27.5	43.4			
Mar. 24, 1879				27.0	27.0	
Mar. 27, 1879						27.0
Apr. 8, 1879						27.0
May 13, 1879						
June 11, 1879	27.5					
June 12, 1879			47.7	29.2	29.2	
June 14, 1879						28.0
June 18, 1879		28.4				
July 8, 1879	30.5	30.7		31.0	30.7	30.5

APPENDIX XVIII.

(See page 191.)

LETTER FROM THE SECRETARY OF WAR,

COMMUNICATING, IN OBEDIENCE TO LAW, THE REPORT OF THE BOARD OF OFFICERS APPOINTED TO EXAMINE THE WORKS IN PROGRESS OF CONSTRUCTION BY JAMES B. EADS, AT THE MOUTH OF THE MISSISSIPPI RIVER.

JANUARY 27, 1879.—Referred to the Committee on Commerce, and ordered to be printed.

WAR DEPARTMENT,
WASHINGTON CITY, *January* 27, 1879.

The Secretary of War has the honor to transmit to the United States Senate the report of the Board of Officers, constituted by direction of the President, to examine the works in progress of construction by James B. Eads, at the South Pass of the Mississippi River, and report thereon, as required by section 4 of the act of Congress approved June 19, 1878.

G. W. McCRARY,
Secretary of War.

The PRESIDENT
of the United States Senate.

ARMY BUILDING,
NEW YORK, *January* 23, 1879.

SIR:—I have the honor to transmit to you herewith the report of the Board constituted by direction of the President, by Special Orders No. 228, Headquarters Army, Adjutant-General's Office, Washington, D. C., October 22, 1878.

Very respectfully, your most obedient,

J. G. BARNARD,
Col. of Engineers and Brevet Maj.-Gen., President of the Board.

Hon. GEO. W. McCRARY,
Secretary of War, Washington, D. C.

1.

[Special Orders No. 228.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
WASHINGTON, *October* 22, 1878.

The following order has been received from the Secretary of War:

By direction of the President of the United States, a board to consist of the following-named officers of the Corps of Engineers is hereby appointed in accordance with the provisions of Section 4 of the act of Congress approved June 19, 1878.

Detail for the Board: Col. John G. Barnard, Col. John N. Macomb, Col. Z. B. Tower, Lieut.-Col. H. G. Wright, Maj. William E. Merrill.

The board, which will be governed by the provisions of the section of the act above referred to, will assemble in New York City on the 11th of December, 1878, and adjourn to meet at the mouth of the South Pass of the Mississippi before the end of that month.

After completing its examinations, the board is authorized to adjourn to such place as it may designate for the preparation of its report.

By command of Gen. Sherman.

E. D. TOWNSEND,
Adjutant-Gen.

Official:
R. C. DRUM,
Assistant Adjutant-Gen.

A.

PORT EADS, *January* 2, 1879.

Mr. JAMES B. EADS:

The fourth section of the act of Congress, approved June 19, 1878, which authorized and directed the President of the United States to convene a board of five engineers of the army to visit the works "in process of construction * * * at the South Pass of the Mississippi River," requires, after examination of the same, that a "full report" be made, embracing the following points, viz.:

1. Progress made in the construction of the works.
2. The probable cost of completion.
3. The results produced.
4. The results that may probably be produced by them.
5. Their probable permanency.
6. "The advisability of any modification of the terms of the act under which said Eads is constructing the said works, so far as regards dimensions of channel through the jetties, and of the terms of payment for the same."

On the second of these points it is obvious that the board cannot report

without first having from you a statement of your plans for "completion," accompanied with such details as to proposed modes of construction as will enable the board to estimate the probable cost. Should you choose to accompany such statement of your plans with your own estimates of their probable cost, it will be acceptable; understanding, however, that they will be regarded as only furnishing toward enabling the board to prepare its own estimate.

It is obvious, too, that on the fifth point, that of "permanency," a knowledge of your plans for completion is likewise an essential.

If, in addition to what you are requested to furnish, in what precedes, you should desire to present your views on the "results that may probably be produced" by the works as you design to complete them, or to suggest any modification of the terms of the act under which you are constructing the works, as regards dimensions of channel and terms of payment, you are invited so to do.

I am, very respectfully, etc.,

J. G. BARNARD,
President of the Board.

B.

PORT EADS, *January* 4, 1879.

SIR :—I have the honor to acknowledge receipt of your letter of 2d instant suggesting the propriety of my supplying the board with such information respecting my plans for completing the jetties as will enable the board to estimate the probable cost of such completion. I am also invited to present to the board my views as to the probable results that will be produced by the works when completed, and likewise to suggest such modification of the law under which I am building them as I may desire.

Availing myself of the courtesy of the board, I herewith submit drawings of the cross-sections of the jetties, in different stations in their length, which represent the dimensions of the work and the plan of construction. I also present herewith drawings of the plan of construction at the head of the pass.

I have made large contracts for the prompt delivery of stone, gravel, cement, willows, machinery, and piles, for the purpose of completing these works in accordance with the drawings herewith submitted, and have commenced the construction of a mixing-house and railway on each jetty, about one thousand five hundred feet from its sea end, for the purpose of preparing and transporting the material to form the blocks of concrete with which jetties are to be consolidated and finished. Each house will contain suitable machinery for the purpose, driven by a steam-engine, to hasten the completion of this part of the work.

I do not anticipate any necessity for modifying these plans in any manner whatever, but intend completing the works in accordance with them. If, however, in the progress of the work I find they can be modified with advantage, I shall avail myself of the right to do so, as provided in the act.

With the plans I present an estimate of the cost of completing the works, which estimate is based upon the prices I am paying for the different kinds of materials, with an additional allowance amply sufficient to cover the cost of putting them in place. Mr. Wright, my book-keeper, will be instructed to

show receipted bills to the board for these various materials, by which the board can learn the prices that I am and have been paying for them. The amount of the estimate is $302,110.67.

With respect to a modification of the dimensions of the channel described in the act, I earnestly hope the board will state the probable size which the normal discharge of the pass is capable of maintaining between the jetties when they are fully consolidated and completed, and that it will also express its views as to the advisability of undertaking to maintain one of greater dimensions, by forcing an increased volume through it. The results which have been developed thus far by the works seem to me to correspond in a remarkable degree with the effects which were anticipated by the commission of 1874, and to indicate that the maximum capacity of the pass was correctly assumed by the commission. To produce the maximum channel described in the act will, I think, involve the necessity of a central depth throughout the jetties of not less than from thirty-five to forty feet.

The natural volume of the pass cannot, I am confident, create so great a depth through the jetties, and if it be insisted upon by the United States, it can only be produced by forcing more water through the pass. This will involve, in my opinion, danger to the jetties, and a disturbance of the regimen of the three passes to an extent that can only be known after it is probably too late to remedy the evil.

I deem it unnecessary to point out in detail to engineers who are so familiar with the hydraulics of the river, the various objections that can properly be urged against the attempt to produce a channel through the jetties by a method which involves the enlargement of the pass itself through its entire length, and which method (directing more water into the pass) is the only one which can permanently maintain such a channel.

One effect of the works thus far completed seems, according to Captain Brown's observations, to have resulted in a diminution of the size of the pass probably equal to about five per cent. of its former capacity, which is, I think, a certain evidence that the quantity of water now discharged by it is proportionately less than it was before the work was begun. To restore the original capacity of the pass, and thus re-establish the disturbed conditions, or equilibrium of the three passes, I am now increasing the thickness of the sill across the head of the Southwest Pass, by which the discharge of the South Pass will be restored to its former volume. When this is accomplished, I shall sill the entrance into South Pass, if it shall appear to be necessary to prevent too great an inflow into this pass. If the maximum channel demanded by the act be insisted upon, I shall have no alternative but to diminish the discharges of the Southwest Pass and Pass à Loutre, by increasing the height of the sills which now control their discharges, until South Pass shall discharge the volume necessary to create and maintain such channel. I believe the natural discharge of South Pass is sufficient to create and maintain a channel through the jetties that shall have a central depth of thirty feet when the jetties are fully consolidated and all leakage through them is prevented; but I do not believe such volume will produce a channel of greater magnitude.

The cost of raising the Southwest Pass and the Pass à Loutre sills sufficiently to produce a thirty by three hundred and fifty foot channel through the jetties has not been included in the estimate herewith submitted. This

would involve an outlay of about $50,000, and would require the present depth over them to be diminished two feet, exclusive of the work now being executed on Southwest Pass sill. This would reduce the cross-section of the volume entering those passes about twelve thousand square feet, and would proportionately increase the cross-section of South Pass.

With reference to the question of modifying the terms of payment for the work, I desire to call the attention of the board to the fact that they were arranged by the Congressional committees when perfecting the bill so as to protect the government against the possible expenditure of a dollar of money until after the experiment of the jetty system should have produced valuable results for commerce. Experience has shown that these payments were wholly disproportioned to the amount of work necessary to obtain the stipulated depths. The attempt to deepen the mouth of the river by jetties is no longer an experiment, so far as the attainment of a permanent channel deep enough to give an immense relief to commerce is concerned, even if it be admitted that the present depth cannot be increased. There is, therefore, I think, no equitable reason why I and my associates should not be paid for the work already done, with the same degree of liberality which the government shows to others who undertake the execution of works for it, where no such risks are assumed as we have encountered. We think we should not now be less liberally dealt with, since the results obtained have demonstrated the great practical value of the works we have executed. If we are allowed ninety per cent. on the amount of work already executed, the account between us and the government would stand thus :

Agreed price of the whole work	$5,250,000
Estimated cost of completing it	362,110
	4,887,890
Less ten per cent. reservation	475,000
	4,412,890
Amount paid by the government (about)	1,600,000
	2,812,890
Additional reservation for the million to be retained for 10 and 20 years	525,000
	2,287,890

Leaving $2,287,890 as the amount actually earned but unpaid for constructing the works, with $1,000,000 in reserve. If it be urged against this statement that the creation of certain dimensions of channel is as much an obligation on our part under the law as that of building the works, I will admit it; but the reason for enforcing this obligation no longer exists, or is at least so greatly modified that to insist upon it now, when the public interest cannot be promoted by its enforcement, seems to us as unnecessary and oppressive as it would have been to insist on the original conditions of payment which Congress modified by the act of June 18, 1878, after being satisfied such modification was just. Its disposition to release us from these oppressive conditions now, so far as the public interest will justify, may be safely inferred, I think, from the

clause in the act which requires the board to report upon the propriety of modifying the size of the channel and terms of payment. But if the progress made by us in producing stipulated depths of channel be alone taken as the only basis for determining the proportion of the work that has thus far been completed (although such method of estimating it would seem manifestly unfair), it can be shown that the pay thus far received falls much below what it should be even under such ruling.

For instance, we were to deepen the bar from eight feet to thirty feet, being a total deepening of twenty-two feet, of which twenty-two feet we have already accomplished fifteen feet, having at present a channel depth of twenty-three feet. This is equal to fifteen twenty-seconds, or nearly sixty-eight per cent. of the total depth.

Sixty-eight per cent. of the price for the completed works is	$3,570,000
Paid by the government	1,600,000
	1,970,000
Less ten per cent. reservation	197,000
Leaving unpaid and already earned	1,773,000

If this sum were authorized to be paid at once by the government, it would still retain $1,877,000, or $877,000 to complete the works, and $1,000,000 reserved to be paid in ten and twenty years. I will add that if this total sum were at once paid me it would not suffice to discharge all of the debts created by me in the construction of the works.

It may be advanced against this computation on the basis of depth alone, that sixty-eight per cent. is an overestimate for what has been accomplished, as it will probably be more difficult to secure the next seven feet than it was to obtain the last seven. This is clearly an error, if the cost alone be considered, because the works are already so near completion. It may possibly take more time to secure this seven feet, but certainly less money will have to be expended. In this connection it may be said that when twenty-five feet shall have been obtained, by far the most valuable part of the depth will have been secured, as all over twenty five feet could be dispensed with without injury to commerce (except possibly on very rare occasions), and, on this view, sixty-eight per cent. is not a high estimate of the commercial value of the proportion of the thirty feet maximum yet to be obtained.

I hope the board will, after due consideration, determine the maximum amount which may be paid to us at this time with safety to the public interest, and will recommend such modification in the terms of payment of the remainder as will provide for its distribution *pro rata* upon each additional one foot of depth that may be hereafter secured, without regard to any specific widths for such depths, inasmuch as each increment of depth must necessarily bring with it a corresponding improvement in the width of channel.

In reporting upon "the results produced" by the works, I respectfully suggest that changes in the depth of the sea-bottom immediately in front of the jetties, and the ability of the works to maintain the channel without the auxiliary aid of dredging, are two questions of such general public interest as to make an expression upon them by the board of great value and importance,

especially as there seems to be still some doubt in the public mind upon them.

I have the honor to be, very respectfully, your obedient servant,

JAS. B. EADS.

GEN. J. G. BARNARD,
United States Engineers, President of the Board, etc.

ARMY BUILDING,
New York, January 22, 1879.

SIR :—The board constituted by Special Orders No. 228, Headquarters of the Army, Adjutant-General's Office, Washington, D. C., October 22, 1878 (of which a copy is annexed, marked 1), assembled at New York on the 11th of December, 1878, and after examination and discussion of the section of the act of Congress by which its proceedings are to be governed, and of other documents referring to their prescribed duties, adjourned to meet at the mouth of the South Pass of the Mississippi on the 30th of December.

The section of the act (section 4, act approved June 19, 1878) requires that—

The board shall visit the works in process of construction by said James B. Eads, at the South Pass of the Mississippi River, and make an examination of the same, and make a full report of the progress made in the construction of the works, the probable cost of their completion, and the results produced, or that may properly [probably?] be produced by them, their probable permanency, and of the advisability of any modification of the terms of the act under which said Eads is constructing said works, so far as regards dimensions of channel through the jetties, and of the terms of payment for the same; which said report shall be submitted to the Secretary of War, to be presented at the next session of Congress.

The subjects upon which the board is required to make a full report are these :

1. Progress.
2. Probable cost of completion.
3. The results produced.
4. The results that may probably be produced.
5. Their probable permanency.
6. The advisability of any modification of the act, etc.

To discuss these subjects in the order named:

1. PROGRESS MADE IN THE CONSTRUCTION OF THE WORKS.

This requires reference to the original design, which was to construct, starting at marginal points on its banks above where the normal channel depth (thirty feet) of the pass itself begins to diminish, dikes or parallel piers (as they are commonly designated) extending thence to the deep water of the Gulf, thus confining the outflowing water in a channel of the same width (nearly) as that of the pass itself until it reaches the deep water of the Gulf, and thereby prolonging *through* the "bar" and to the Gulf the normal depth (nearly) which the pass maintains between its natural banks. These parallel piers or dikes,

technically called "jetties," are essentially, then, an artificial prolongation of the natural "banks" to deep water in the Gulf. From the land's end (East Point) of eastern shore to thirty-five feet depth in the Gulf (which was about three hundred feet beyond the crest of the bar) was a distance of eleven thousand nine hundred and forty-one feet, which figures define the length of the east jetty as originally designed and marked out by piles.

The natural bank on the west side of the South Pass extended seaward four thousand feet farther than the natural eastern bank; the initial point of the west jetty was, therefore, taken about that distance below the origin of the eastern one; hence the required length of the west jetty was eight thousand feet nearly.

The average width between banks of the pass itself is about seven hundred feet; which width, by the act of March 4, 1875, is fixed as the minimum between the authorized jetties.

The origin of the west jetty was established some distance (about six hundred feet) from the west bank; hence it became necessary to connect this point with the natural west bank by a dam of this length, built at right angles to the jetty, to which the name of the Kipp dam was given.

The original design therefore consisted of "east jetty," eleven thousand nine hundred and forty-one feet in length (two and a half miles, nearly), a "west jetty" eight thousand and fifty feet in length, and the "Kipp dam." The plan of "construction" was, in its main features, essentially that developed by long experience in Holland for dikes, dams, and jetties, on like yielding substrata, viz., a broad foundation stratum of willows or other suitable brush, formed into "mattresses" (technically so called), on top of which was built a superstructure of tapering section, of alternate strata of mattresses and stone or gravel.

If we except three hundred and thirty feet in length of extreme end of the originally designed east jetty, and two hundred and eighty feet in length of the west jetty (reducing the total lengths of these jetties to eleven thousand six hundred and seven thousand seven hundred and seventy feet respectively), the jetties, throughout the lengths just mentioned, and the dam have been actually *built up* to the level of average high-water, or somewhat above that level, and, owing to subsidence, supplementary elevations of willows and stone have from time to time been added. At present the seaward ends for about one thousand five hundred feet are overflowed at high tide, and even at low water through a portion of less extent.

Pages eight and nine of the annual report upon the improvement of the South Pass, give for east and west jetty the actual height (July 1, 1878) above "average flood tide" throughout their whole length. It will be seen that the outer ends and a few points higher up are now at various depths below high tide. The extreme end of the east jetty is reported by Capt. Brown to be eleven feet below; at the date of our visit the lower ends of both jetties for one thousand feet or more were more or less submerged at flood tide. Higher up the two jetties were found to be from three-tenths to one foot or one and a half feet above high tide.

Page ten gives the same particulars for the "Kipp" dam, which is throughout from one-half to one foot above flood tide.

After the mention just made of "supplementary elevations" added from

time to time to the jetties, to compensate for subsidence, it is proper to say a few words on this point.

Owing to the well-known character of the formation at the mouth of the Mississippi, much subsidence was expected. We have no accurate record of the total settlement of the various parts from the commencement. But on page 19 of the annual report already cited, Capt. Brown has given them for the year ending July 1, 1878. The amount of depression, superficial destruction by storms being eliminated, due to actual settlement *and* compression of willows is, beginning at East Point, one-half foot, gradually increasing to three and one-third feet at the extreme end of the east jetty.

It is impossible to eliminate the compression of willows, to show how much of the above is due to pure *settlement;* but, from the corresponding depression of the heads of the piles along the center portions of the jetties, it would seem probable that it is mainly due to "settlement." On page 2 of the fifth report, Major Comstock gives the settlement of certain piles along the last one thousand feet of the east jetty, counting from the *old end*, and therefore covering the outer six or seven hundred feet of this jetty as it is at present. Between July 18 and October 21, 1876, three months, the outermost pile had settled 2.55 feet, the innermost 0.67, the gradation being progressive.

On the west jetty the observations began about two hundred and seventy feet within the present end, and extended *back* along two hundred and fifty running feet of the jetty, the observed settlements graduating from 1.60 to 0.80 feet. Owing, however, to the great subsidence of mattresses and piles at the outer ends at first fixed, the terminal points were (as before stated) withdrawn three hundred and thirty and two hundred and eighty feet respectively, by which withdrawal the jetties now terminate inside the crest of the old bar—the eastern on the very edge, the western at two hundred feet inside of it.

Inasmuch as a full statement of the "progress" of the construction can scarcely be made without reference to the repeated partial reconstructions on account of subsidence, we have been led to develop that subject so fully. For details of actual construction, we refer to the third report of Major Comstock, and to map of No. 2 of the same report, which exhibits various sections of the jetties as built, and makes it unnecessary that we should swell this report by further description.

Up to November 1, 1878, there had been consumed in the construction of the two jetties and of the Kipp dam, as stated by the engineers employed by Mr. Eads, three hundred and ten thousand eight hundred and thirty cubic yards of mattresses and willows, and fifty-four thousand five hundred and sixty-five cubic yards of stone, mostly small stone.

By decision of the Attorney-General, January 17, 1877 (Ex. Doc. 28, Part 1, H. R., Forty-fourth Congress, second session), the channel through the shoal at the "head of the pass" is made a part of the "South Pass," through which a "navigable depth" is exacted by the act of March 3, 1875. The work at this locality had, however, been undertaken by Mr. Eads simultaneously with that on the jetties. A deflecting dike or "catchwater" was designed and commenced, running from the eastern margin of the entrance to the pass, a distance of about three thousand feet, in a course starting northerly, curving to the westward; but a channel into the west entrance developing itself, which vessels began to use, the plan was abandoned, and the channel east of the island was

closed by a dam. Dikes (called "T-head dams" on charts) were run out from the island and from the west bank, and they now define the present channel or entrance. The island or eastern T-head, about one thousand six hundred feet long (originally eight hundred feet longer), running northwest by north from the head of the island, consists at present only of a row of piles and a single layer of mattresses on the bottom.

The west T-head, eight hundred feet distant from the eastern one, starts from a point about one thousand two hundred feet above the origin of the latter, and four hundred feet distant from the west shore, with which it is connected by a dam. Except the last three hundred and fifty feet, this T-head is built up above flood tide with five or six tiers of mattresses loaded with stone on a double foundation layer of two mattresses side by side. The extension of three hundred and fifty feet has at present its foundation layer only. The dam above mentioned has been built up above high-water level and loaded with stone.

The permanent dam, five hundred and fifty feet long, extending from the lower part of the island to the east shore and stopping the old east channel, has been built up above high water and well loaded with stone.

The foregoing described constitute the system of "works" properly belonging to the head of the pass. Auxiliary thereto, mattress "sills," so called, have been laid on the bottom across the two great passes. The one across Southwest Pass runs from the west shore (from which a spur-dam about four hundred feet long is first thrown out) to a point near the upper end of the west T-head. The entire length, including spur-dam, is about three thousand two hundred feet. The one across the Northeast Pass runs from the end of the old east dike to the opposite shore; length, about three thousand feet. They consist of a single mattress layer seventy feet wide and about thirty inches thick, weighted with stone.

In these various works at the head of the pass have been consumed one hundred and forty-one thousand one hundred cubic yards of mattresses and willows, and ten thousand seven hundred and fifty-five cubic yards of stone, as stated by Mr. Eads's engineer.

The foregoing is deemed a sufficiently full report of the "progress made in the construction of the works."

In what precedes we have made no mention of the wing-dams which have been constructed at various times. Their maintenance not being contemplated as permanent works, it is understood they have already subserved the purpose intended, of accelerating the process of channel formation.

2. Probable Cost of Completion.

Inasmuch as the act of Congress by which the contract was made with James B. Eads for improving the South Pass of the Mississippi River expressly stipulates that the contractor should have perfect freedom as to the means to be used in obtaining the depths and widths of channel named in the act, estimates of the cost of completing the works could only be made after the board had been officially informed by the contractor of the methods which he purposed using. An official letter requesting this information was sent to the contractor (copy attached and marked A) as soon as the board arrived at Port Eads. His reply (copy attached and marked B), with the accompanying

drawings, fully sets forth his present plans and methods of completing the works. These plans are necessarily subject to modification should experience in carrying them into effect indicate a necessity therefor. Whether such a necessity will arise cannot be foreseen, and therefore estimates must be based on the plans as they now stand.

The following is a brief statement of the work proposed :

1. The top of the east jetty is to be raised to the height which the contractor deems desirable, which varies from one and a half feet above average flood-tide at East Point to seven feet nine inches above the same plane at the sea end. The upper part of this jetty, from the point five hundred feet below its origin (to which point the jetty may be considered as finished) to a point nine thousand two hundred feet below, is to be raised to the level of one and a half feet above average flood-tide, and finished by a rounded paving of riprap stone. The next thousand feet in length is to be capped by a low wall of rubble masonry. The remaining portion of this jetty to its sea end, a distance of one thousand five hundred and fifty feet, is to be capped with large blocks of concrete built in place, on which at a later date a continuous parapet of concrete is to be built. The river and sea slopes of this jetty and its sea end are to be protected by mattresses covered with stone, additionally strengthened at the sea ends for some distance back by crib-works of palmetto logs filled with stone.

2. The west jetty is to be treated in a similar manner, the changes in the method of finish being made at points opposite those at which the changes are made on the east jetty. The protections designed for the sea end and for the slopes of the west jetty are not so extensive as those for the east jetty, the latter being apparently considered as more exposed to injury.

3. The training-walls at the head of the South Pass (called on the maps "T-head dams") are to be improved. The eastern training-wall, on which but little work had been done, is to be raised above the surface of the water. The portion at the head of the western training-wall, now consisting of piles and one layer of mattresses, is to be completed.

4. The obstruction now in the Southwest Pass is to be increased by the superposition of other mattresses until the cross-section of this pass is made about twelve thousand square feet less than it was after the original sill had been laid.

5. The dam closing Grand Bayou is to be maintained by such additional work as may from time to time become necessary.

Mr. Eads estimates the cost of doing the work thus summarily indicated at three hundred and forty-nine thousand six hundred and forty-one dollars.

The board have carefully gone over the details of this estimate, and believe that it is substantially correct. They differ from Mr. Eads in some minor items of cost, but these differences are amply covered by the fifty-eight thousand two hundred and seventy-three dollars allowed for contingencies. The board is, therefore, of the opinion that the work indicated by Mr. Eads can probably be done for his estimate, provided no extraordinary contingencies intervene.

This at once brings up the question whether the completion of the indicated works is a substantial completion of the original project, and may be so considered in questions of compensation.

When may the works at the South Pass be considered as completed?

A careful study of the act of Congress under whose authority the original contract was made with Mr. Eads shows that there is no mention of any specific work to be done by the contractor. The act authorizes him to construct "such walls, jetties, dikes, levees, and other structures, * * * as he may in the prosecution of said work deem necessary." It also expressly states that "said Eads shall be untrammeled in the exercise of his judgment and skill in the location, design, and construction of said jetties and auxiliary works." The only limitation on the contractor is the provision that the jetties "shall not be less than seven hundred feet apart."

The whole contract is based on results. Certain specified sums were to be given to the contractor for certain depths of channel obtained by him. It was only required that the jetties should be "permanent and sufficient" "to create and permanently maintain" these various depths, the test of the permanent completion of the work being the creation and maintenance for twenty years of a channel thirty feet deep and three hundred and fifty feet wide. This is the standard of completion established by law, and there is no power short of the power that made the law, that can change the standard.

With this view of the law and the duty of the board under the same, it is unable to make any other statement of the progress that Mr. Eads has made toward the completion of the jetties than the fact that he has obtained a depth of twenty-three feet on the bar, and that there yet remains to be obtained seven more feet of depth, and a very considerable increase in width.

While the board adopts the estimate of Mr. Eads for the work which he still proposes to execute, it does not consent to his claim that that amount of work will even complete his project. The yielding character of the bottom underlying the jetties for the last two thousand feet, and especially at the extreme outer ends, is such that the works have been constantly sinking into it, requiring frequent additions of brush and stone to bring them above the water surface, and it seems very certain that the final subsidence has not been reached, and that the works now proposed will require, from time to time, similar additions, the cost of which must be added to his estimate. What the cost of such additions will be cannot be foreseen. And further, even if the project as now proposed by Mr. Eads were completed, it does not follow that the works would satisfy the conditions of the law by producing a channel of thirty by three hundred and fifty feet. The opinion of the board on this point will be found farther on.

3. The Results Produced.

The average width of the South Pass, between banks, is about seven hundred feet; the depth, so long as that width is maintained, is about thirty feet. At East Point, where the eastern bank terminates, and where the width was already increased to eight hundred and fifty feet, the bank confinement ceased; thence to the crest of the bar, two and one-quarter miles distant, the depth gradually diminished to about nine feet (average flood tide), the last half mile before reaching the outer crest having, nearly uniformly, only this small depth.

The results produced by the works may be well exhibited by the following table, giving the depth of water in feet and tenths that could be carried through

each section of two thousand feet below East Point at different dates, commencing June, 1875 (the date of the commencement of the works), to December 28, 1878. By following with the eye each column downward, the progressive increase in depth of the particular two thousand feet section of the channel indicated at the head will be readily observed. (See Appendix XVII.)

The last column is more especially a test one, since it gives the bar-depth or shoalest part of the channel. The maximum bar-depth that has been obtained prevailed December 14, 1877, when it was 23.7 feet. At the date of the latest survey, December 28, 1878, it was twenty-three feet. This slightly diminished bar-depth by no means indicates actual retrogression in the progress of "results." On the contrary, there has been constant progressive general improvement in the jettied channel, at no time more evident than at the present.

At the date last named a depth of twenty-four feet, with a channel width of three hundred feet, extended down to within two thousand feet of the jetty ends; and the same depth, with a channel width of two hundred feet, almost to the very ends. Thence to the same depth outside was a distance of but sixty feet, with a navigable channel of twenty-three feet intervening.

The twenty-five foot channel has nearly the extent of, and not much less width than, the twenty-four foot channel. From its terminus inside to the same depth outside of the bar there is but an interval of one hundred and sixty feet.

The twenty-six foot channel extends (with a break of only one hundred and fifty feet) down to within one thousand feet of the jetty ends. Above the single interruption mentioned, which is three thousand feet from the ends, the twenty-six foot channel has in its narrowest parts one hundred and one hundred and fifty feet width; in the widest three hundred and fifty and seven hundred feet, the latter at the site of the so-called "deep hole."

The depth of twenty-seven feet is found at various points in the channel down to very near the jetty ends.

If we compare the above with the chart of a year's earlier date (December 5, 1877), we find a general improvement of navigable channel through the lower six thousand feet. There is twenty-four feet where there then was twenty-two feet; that is to say, a general increment of the channel depth by two feet, accompanied by rectification and widening of areas of lesser navigable depths; there being for the twenty-two foot depth two hundred and thirty feet width at the bar, and a general width within of over four hundred feet. While the abnormally "deep hole" itself has filled from extreme depth of eighty feet to sixty-five feet, the channel for one thousand feet below the hole has deepened by an average of ten feet (*i.e.*, from depths of twenty-eight feet and thirty-eight feet to depths of thirty-eight feet and forty-eight feet). (The deep hole, so called, above began to form two years ago, commencing near the origin of the west jetty and extending about two thousand feet down the jettied channel. Various causes have been assigned, eddies being the most prominent. Depths of over one hundred feet have been exhibited.) As to the channel from Kipp Dam (at upper limit of the hole) up to the beginning of the jetty works at East Point, we find for two thousand five hundred feet upwards an average deepening of from six to seven feet (extreme twelve feet), above which to East Point the depth of about thirty feet has remained pretty constant.

At the *head of the passes* the result of the works has been the procuring of a channel depth of twenty-two feet where there was, over the shoal, but fourteen or fifteen feet. If we compare the present condition with the chart of December, 1877, we find that while the actually navigable depth is not much changed, the distance between the twenty-four foot curves at T-heads and above the same respectively has increased from three hundred and fifty to eight hundred feet; this augmentation of the *bar*-width taking place both inwardly and outwardly, but in much the greater proportion outwardly (*i.e.*, on the Southwest Pass margin). Between the training walls the channel may have somewhat improved, not by increase of maximum depths, but by the diffusion of the current more equally over the intervening space.

4. Results that may Probably be Produced.

It is a difficult matter to respond satisfactorily to this requirement of the law, inasmuch as the efficient causes cannot be precisely defined or measured. Reference to opinions of engineers who have recommended the resort to jetties, and developed their views as to depths which should be obtained by the means proposed, furnishes one basis of judgment. Reference to the *actual results*, combined with the progress and present condition of the works, furnishes another. The trial of the jetty system at the South Pass, or at least a further study of the subject, before undertaking the construction of a ship canal, was first recommended in the minority report of the Board of Engineers of 1873, with the expression of opinion that twenty-five feet at low water might be attained; the practicability of terminating the jetties inside the bar crest (instead of encountering the great expense and doubtful practicability of prolongation to deep water) being assumed or supposed probable.

The Board of Engineers constituted by act of June 23, 1874, "to determine the best method of obtaining and maintaining a depth of water sufficient for the purposes of commerce, either by a canal from said river to the waters of the gulf, or by deepening one or more of the natural outlets of said river," proposed, by the extension of jetties, nine hundred feet apart, to the depth of thirty feet outside, to obtain provisionally a channel depth which would, as was estimated, gradually shoal by bar advance in about ten years to twenty-five feet depth, when the jetties must be extended one thousand feet seaward to reach thirty feet depth again. The present jetties are about nine hundred and fifty feet apart, and terminate, the eastern almost on the outer edge of the bar, where there was originally but fifteen or sixteen feet of water; the western, about two hundred feet within the outer edge, where there was but seven or eight feet of water. The conditions, therefore, by which the engineers of the Board of 1874 expected to get, provisionally, thirty feet depth, do not, in the existing arrangement, fully obtain.

Mr. Eads, in his letter to this board, herewith appended, states:

"I believe the natural pass is sufficient to create and maintain a channel through the jetties that shall have a central depth of thirty feet when the jetties are fully consolidated and all leakage through them is prevented; but I do not believe such volume will produce a channel of greater magnitude."

Though the ground for this belief is not here stated by Mr. Eads, it is understood that he relies on the fact that the pass in its natural condition

maintains a depth of thirty feet in its channel. He believes that the jetties will carry out that depth, undiminished, to the sea. This, too, was admitted or assumed by the Board of 1874, *provided always*, the jetties, nine hundred feet apart or less, be extended to or beyond that natural depth in the gulf. This proviso is not fulfilled, as we have seen, by the existing jetties.

The foregoing refers to *à priori* opinions. Turning now to the results actually and progressively obtained, coupled with the stage of construction and present condition of the jetties, the facts of the case have been stated under the proper head.

The jetties since their commencement have produced an increase of bar (or minimum navigable) depth from nine to twenty-three feet; and if the last twelve months have shown no actual increment of that particular element, yet there has been (as already fully set forth) a most decided improvement throughout the whole jettied channel length. There is ground to look for further improvement, coupled with increase of bar depth, which, to twenty-five feet, requires the cutting through of a bar of only one hundred and sixty feet width. But the jetties have not yet (as seen in our statements on "progress, etc.") acquired their full action. The outer ends, though more than once raised, are still submerged. According to Capt. Brown, Eighth Report, p. 31, "at least twenty per cent. of the water passing land's end at East Point escapes over the jetties and through the meshes of the mattresses at average flood-tide." Mr. Corthell, resident engineer under Mr. Eads, estimates the escape at twenty-five per cent. By far the greater portion of this escape takes place along the lower one thousand or one thousand five hundred feet of length. Moreover, the temporary effect of the operations at the jetties at Grand Bayou, and at the head of the passes, has been to diminish the discharge of the pass by ten or twelve per cent. The raising and consolidating the jetties at their outer ends will in great measure prevent the loss attributed to imperfect confinement; the volume originally entering the pass at the head may probably be restored.

The foregoing considerations, and the facts already stated under the head of "results actually observed in the progress of channel development during the last twelve months," induce us to think that if the jetties were well consolidated and raised sufficiently high to prevent leakage and overflow, a considerable increase of navigable depth would result. We cannot state that in our opinion it is a "probable result" that the depth of thirty feet will be attained, as assumed by Mr. Eads. What the limit will be cannot be positively announced. That it may attain twenty-five or twenty-six feet is all we can venture to expect as a depth which shall permanently maintain itself; and as past experience shows annual fluctuations amounting to about two feet, a permanent channel of twenty-five or twenty-six feet will require an occasional channel of twenty-seven or twenty-eight feet.

With regard to the head of the passes, the considerable widening of the bar or shoal between twenty-four feet inside and twenty-four feet outside during the last twelve months is an unfavorable result. The work designed by Mr. Eads, and embraced in his estimate for "completion," and now commenced, consisting mainly in the raising by additional mattresses the sill of the Southwest Pass, with the view of restoring the lost inflow to the South

Pass, and deepening the entrance, may accomplish the result expected. We have not full confidence, however, that that measure alone will do so.

In connection with the "probable results" of jetty construction upon which we are directed to report, there is one to which pre-eminent importance has been attributed, and which should not be here overlooked—that of bar advance. The Board of Engineers of 1874, in recommending the jetty construction at the South Pass, assumed that the normal rate (supposed to be one hundred feet per annum) would be maintained after the pass was jettied, and hence that to maintain a depth of at least twenty-five feet, the jetties must be prolonged every ten years. One of the main arguments used against the resort to the jetty system has always been that a greatly increased rate of bar advance will ensue. On this point we refer to the Seventh and Eighth Reports of Captain Brown, and to his Annual Report of June 30, 1878. By the Seventh Report, page 30, it is shown that over a fan-shaped area of one and one-quarter square miles immediately seaward of the ends of the jetties, there had been between June 20, 1876, and June 22, 1877, a mean "fill" of four-tenths of a foot. Parts of this area had scoured (*i.e.*, had become deeper); in four of the twenty-one sections there had been, on the contrary, a large "fill;" the average total result having been, as just stated, a slight shoaling of 0.4 foot. Over this same area (page 15, Annual Report) there had been in the subsequent twelve months from June, 1877, to July, 1878, a scour (*i.e.*, increase of depth) averaging 1.8 feet.

By the table, p. 33, of the Eighth Report, it is shown that in that portion of the thirty-foot curve lying seaward, between the prolongations of the jetties, an advance of one hundred and thirty-two feet had taken place so early as October, 1875, soon after the jetties were commenced, and before any impression had been made on the bar. During the subsequent period of two years there had been fluctuations, the advance reaching (July 28, 1877) the magnitude of two hundred and forty-two feet, followed by a retrogression to one hundred and eight feet, December 15, 1877. This last was followed by another retrogression (table, page 18, Annual Report) to sixty feet in the early summer of 1878, succeeded by an advance, July 15, to one hundred and forty feet.

The foregoing, referring to the portions of the thirty-foot curve included between the prolongations of the jetties, affords no proof of *progressive* advance. If, in this connection, we take into account the position of the thirty-foot curve outside the jetties (and this is evidently a better test), there is shown, instead of advance, an absolute retrogression. Or, again, if we have reference to deeper curves, Captain Brown's surveys (Annual Report, table, page 15) show that from June, 1877, to July, 1878, the forty, fifty, sixty, eighty, ninety, and one hundred foot curves had drawn in towards the ends of the jetties the respective distances of one hundred and seventeen, two hundred and twenty-eight, one hundred and ninety, sixty-five, seventy-one, and one hundred and eighty-three feet; the seventy-foot curve alone showing advance into the gulf (forty-six feet). The actual results, therefore, so far as we know them, do not justify the predictions of accelerated bar advance. On the contrary, they show a disappearance of bar material from the front of the jetties.

5. Probable Permanency.

Wave (or storm) *action* of the sea and *decay* or *destruction by the teredo* of

e willow mattresses are the principal destructive elements to be mentioned. n additional element of deterioration, not peculiar to the location, but supsed to be so prominent as to involve the question of permanence, must also noticed. The jetties, except the extreme ends and contiguous portions for out fifteen hundred feet inward, are so well sheltered by shoals that wave tion, except on those portions, has little effect. On the sea-ends the effect as been considerable, but mainly superficial, destroying more than once the pper course or courses of mattresses, and washing off and scattering the ones (mostly small) which have been repeatedly applied to the top surface. Vave action is by no means as violent here as in similar exposures on the tlantic coast. We see no reason to doubt that the thick concrete capping Ir. Eads is now commencing to apply (work having already begun on the pper portions), flanked by enrockments of heavy stones on palmetto-log grilages overlying the original marginal mattresses, will resist sea action.

Wood of all kinds considerably submerged is sufficiently secure against decay.

Experience here shows that for about seventeen hundred feet inwards from he jetty ends the teredo destroys rapidly all exposed wood (including in this erm the willows of the mattresses) lying more than four or five feet below the urface of the water. Evidence enough of its attacks upon piles and willows xists. But the teredo does not attack wood where the free access of sea-water s impeded. Those portions of a stick buried in mud or sand, or packed round with mud or sand, are secure. We have no reason to believe that the eredo has penetrated or can penetrate far into the interior of the mattress ourses ; we have pretty good reason to believe that the foundation mattresses re and will remain secure ; and probably also the bulk of the interior of the asses of willow-work.

In what we have said under the head of "progress," we have given sufficiently full details concerning settlement. It is still very great at the outer nds, though very much less in all those portions more than two or three thouand feet from those ends. That additional superficial applications of stone or oncrete will be necessary to the structures we must expect.

In the ordinary sense of the word permanency, *i.e.*, capability of endurnce of destructive forces, the works may be said to possess the attribute, to a easonable degree, for work of the kind thus situated. As regards the outer nds, it is yet early to predict to what extent or how long renewals of height o compensate the still progressing settlement must be resorted to.

. Advisability of any Modification of the Act as Regards Terms of Payment and Dimensions of Channel.

As the United States has not suggested or desired any modifications of the rms of the act in these or other particulars, it follows that any change must e for the benefit of the contractor, and it equally follows that no change hould be made unless justice to the contractor should demand it. This leads to n examination of the claims advanced by him for a modification of the terms f the act of 1875, by which the contract was awarded to him for improving ie South Pass of the Mississippi River, so as to give a channel of twenty-six et depth at its head, and a channel of thirty by three hundred and fifty feet its outlet into the gulf.

The Board of 1874, instituted by act of Congress to determine the best method to secure an outlet from the Mississippi River to the gulf, either by a canal or by the improvement of one of its natural outlets, reported in favor of improvement of the South Pass at an estimated cost of $5,342,110, declaring that while its estimate was designed to cover every possible contingency of cost, it was believed the work could be done for a much less sum. No reason is known why Congress, which adopted this recommendation, should not have left the execution of the work to its own agents, except that the present contractor, Mr. James B. Eads, offered to accomplish the results contemplated by the board without payment unless those results were secured. It would seem, therefore, that this proposition of payments for results only influenced Congress to award the contract to Mr. Eads, instead of leaving the execution of the work to its usual agents. Taking this principle of no payments except for results, as the motive which governed Congress in awarding the contract to Mr. Eads, we are prepared to consider his claims to aid beyond what the original contract gives him, and what the supplementary act of June 19, 1878, advances to him.

His claims are based, first, on the assumption that the work already executed and the results attained are greatly disproportionate to the payments he has received; and, second, on the financial embarrassment under which he labors, in consequence of his large expenditures in excess of his receipts.

In regard to the results accomplished, Mr. Eads claims that as he was to provide a channel of thirty feet where there was only eight feet originally, and as he obtained a channel of twenty-three feet, he has accomplished fifteen twenty-seconds of the result promised, and that he should be paid in that proportion. But it should be remarked that a channel of less depth than eighteen feet at South Pass was not necessary, and it is clear from the contract and other evidence that Congress did not design to pay for any channel of a less depth than this. The useful result accomplished is, therefore, a channel from eighteen feet to twenty-three feet, and the proportion to the whole depth of thirty feet is five-twelfths. If the required widths of the prescribed channels and the failure to maintain the above full depths during twelve months be also taken into consideration, this proportion of five-twelfths will be largely in excess of the truth. But the contractor has been paid for results obtained, and had advances made to him up to date, aggregating $1,686,066, or about five-twelfths of the amount to which he will be entitled on securing a thirty-foot channel, leaving out of consideration the sum of $1,000,000, to be retained for a series of years as security for the maintenance of the channel. On the other hand, neither the results of our own examinations nor the records and estimates of the inspecting engineer officer warrant us to believe that the amounts already paid are disproportioned to the amount of work actually done.

Financial embarrassment on the part of a contractor is not usually considered by the government as a sufficient reason for an advance of money beyond the provisions of the contract; but as Congress has already authorized the advancing to Mr. Eads of $1,000,000, and as that sum may not be sufficient for the work still to be executed according to Mr. Eads's present project, we would recommend the advance of a further amount, not to exceed the $250,000 remaining of the $500,000 due on the attainment of a channel twenty-six by three hundred feet: the money to be expended under conditions similar to those imposed by the third section of the act of June 19, 1878.

every additional foot in depth of channel is of substantial benefit to erce, we would suggest the advisability of a change in the terms of pay- in the original act, so as to allow of payments for each additional foot l, instead of for every two feet, the channels and payments to be as shown following table:

Present system.			System recommended.		
nel.	Payments.	Payments for twelve months' maintenance.	Channel.	Payments	Payments for twelve months' maintenance.
t.			*Feet.*		
350	$500,000	$250,000 with 6 per cent. int.	27 by 325	$250,000	$125,000 with 6 per cent. int.
			28 by 350	250,000	$125,000 with 6 per cent. int.
350	500,000	$500,000 with 5 per cent. int.	29 by 350	250,000	$250,000 with 5 per cent. int.
			30 by 350	250,000	$250,000 with 5 per cent. int.

view of our recommendation that Mr. Eads be provided with sufficient to complete his work according to his own programme as explained to id of his expressed ability to obtain virtually the depths and widths of els prescribed; and further, as but a short time need elapse before results npleting his plans will be made manifest, this board think it premature ommend at this time any changes in channel dimensions as required by ntract.

Summary.

ie opinions which the board have given in the above report may be con- d into the following summary:

ogress.—The east jetty has been built to a distance from East Point of two and a quarter miles. The west jetty terminates opposite the east jetty, s total length is only about one and a half miles; the difference being the greater extension of the natural banks on the west side of the pass. listance in the clear between the jetties is about nine hundred and fifty Both jetties, to within one thousand five hundred feet from their sea- are well advanced toward completion, but it is desirable that they should some portions raised and compacted to prevent the current passing so through them. The outer one thousand five hundred feet of each jetty te deficient in height and compactness, allowing the escape of a large ntage of the water of the pass, and require, therefore, to be raised and lidated quite materially, and especially so at the sea-ends. Much mate- as been expended on these ends, but they continue to settle. The outer hundred and thirty feet of the east jetty as originally built and the outer undred and eighty feet of the west jetty have altogether disappeared, he contractor has decided not to attempt to rebuild the lengths thus lost. ipp's Dam, which connects the starting-point of the west jetty with the al west bank, is in good condition.

The dam across Grand Bayou has settled, and will require some building up from time to time in consequence of subsidence.

The works at the head of the pass, where built above water, are in good condition, but some portions remain to be completed, and some additions are contemplated.

Probable cost of completion.—It is impossible to state definitely the cost of completing a work that by its nature is indefinite. Mr. Eads, in his estimate, proposes to make certain repairs and additions for the sum of about $350,000. The board agrees with him that the sum named will do the work estimated for; but it is of opinion that, on account of settlement and other causes, the indicated work will not complete his project. It is unable to predict what will be the resulting depth on the bar, and as the only standard of completion is the attainment of a channel over the bar thirty feet deep and three hundred and fifty feet wide, it follows that an estimate of the probable cost for works necessary to produce such channel, if it ever can be produced, cannot now be made.

Results produced.—On the 28th of December, 1878, there was twenty-three feet depth over the bar at the mouth of South Pass. Although the depth over the bar is eight inches less than it was a year ago, the bar is narrower, and there has been a marked general improvement in the channel within the jetties. It is much more regular in form, and there has been an average increase in depth of two feet in the lower part of the jettied channel, and of from six to ten feet in the upper part. Outside of the jetties there is no present appearance of bar advance, and though during the past year soundings indicated variable conditions during different months, at the end of the year a scour of twenty-two inches is shown in the one and one-quarter square miles just seaward of the jetties, where during the preceding year there had been a resultant average fill of five inches.

The channel at the head of the pass has somewhat deteriorated during the past year. The depth over the shoal at this place is about the same that it was a year ago (twenty-two feet), but the bar, which was then three hundred and fifty feet wide, is now eight hundred and fifty feet wide.

Results that may probably be produced.—The board is of the opinion that if the jetties are raised and consolidated, so as to confine to the channel-way the greater part of the water now escaping by lateral waste, it may be possible to procure a depth of twenty-five or twenty-six feet over the bar, without regard to width, which corresponds to occasional depths of twenty-seven or twenty-eight feet. At the head of the pass Mr. Eads expects to procure the depth of twenty-six feet required by the contract by still further diminishing the cross-section of the Southwest Pass and Pass à Loutre, if necessary. The board is not fully confident that that alone will suffice.

Probable permanency.—The jetties may be considered as fairly permanent, except the outer ends, for a distance of about fifteen hundred feet. Here the chief difficulty is due to the softness of the bottom on which the jetties rest. Experience indicates that they will continue to settle, and will therefore require to be raised from time to time. When this subsidence will cease it is now impossible to predict. All the other works may be considered as fairly permanent, or can be made so. What repairs will be needed on them from time to time will be moderate in amount and easily made.

Advisability of any change in the contract in regard to terms of payment nd dimensions of channel.—As the gain of each foot in depth of channel is f much importance to commerce, the board recommends that the act of 1875 e so amended as to authorize the payments for each foot instead of two feet, he aggregate to be paid remaining the same, and, as the contractor represents imself as laboring under serious financial embarrassments, occasioned by rge outlays beyond what he has received, which will prevent his prosecution f the works toward completion, beyond what can be done with the advances o him already authorized by Congress, the board further recommends an dditional advance, if needed, to complete his project, of not exceeding two undred and fifty thousand dollars, the expenditures to be made according to he conditions prescribed by section 3 of the act of June 19, 1878.

In view of the various considerations presented in the report, and of the onfidence expressed by Mr. Eads of his ability to secure the ultimately required channel of thirty by three hundred and fifty feet by works the cost of which will be amply covered, according to his estimates, by the additional two hundred and fifty thousand dollars which we have advised to be advanced to him, the board does not recommend any further changes in the terms of payment or dimensions of channel required by the contract.

Respectfully submitted.

J. G. BARNARD,
Colonel of Engineers and Brevet Major-General.
J. N. MACOMB,
Colonel of Engineers, United States Army.
Z. B. TOWER,
Colonel of Engineers, Brevet Major-General.
H. G. WRIGHT,
Lieutenant-Colonel of Engineers, Brevet Major-General.
WM. E. MERRILL,
Major of Engineers and Brevet Colonel.

Hon. GEO. W. MCCRARY,
Secretary of War, Washington, D. C.

APPENDIX XIX.

(See page 194.)

REVIEW

BY

JAMES B. EADS,

OF THE

REPORT

OF THE

BOARD OF U. S. ENGINEERS APPOINTED UNDER THE ACT OF CONGRESS APPROVED JUNE 19, A.D. 1878.

THIS report, although in some respects objectionable (as will hereafter be shown), effectually settles several important questions, which have been much controverted. These will be first considered.

RESULTS IN FRONT OF THE JETTIES.

Prominent among the evils which were prophesied by the enemies of the jetties, was that of the formation of a bar at their mouth. It was declared that if a deep channel *could* be obtained it would have no permanent existence, but would soon be rendered valueless by an advance of the bar. So persistent has been the cry of BAR ADVANCE, in official and unofficial publications, and so widely has it been circulated through the medium of the press of the country, that these predictions have given rise to grave doubts upon the subject, in the minds of many of those who were deeply interested in, and who sympathized with this effort to give relief to the commerce of the Mississippi River. Facts are not wanting to dispel these doubts. The reports from time to time of the government officer in charge of the work (Captain Brown), the charts which he submitted from official surveys made by himself, conclusively demonstrated the utter falsity of all allegations in regard to a "bar advance;" but, in the face of these reports and accompanying charts, the enemies of the work have persisted in repeating their assertions to the contrary. The report of the Board of Engineers, which we are now considering, certainly puts for-

rer at rest this much-vexed question, and dispels all doubt upon the subject. a considering this question of "bar advance," the board unanimously says:

"In connection with the 'probable results' of jetty construction, upon hich we are directed to report, there is one to which pre-eminent importance as been attributed, and which should not be here overlooked—that of bar advance. * * * * If, in this connection, we take into account the position f the thirty-foot curve outside the jetties (and this is evidently a better test), here is shown, instead of advance, *an absolute retrogression.* Or, again, if we ave reference to deeper curves, Captain Brown's surveys (Annual Report, table, . 15) show that, from June, 1877, to July, 1878, the 40, 50, 60, 80, 90, and 100 eet curves had drawn in toward the ends of the jetties the respective distances f 117, 228, 190, 65, 71, and 183 feet, the seventy-foot curve alone showing advance into the gulf (forty-six feet). *The actual results, therefore, so far as we now them, do not justify the predictions of accelerated bar advance. On the contrary, they show a disappearance of bar material from the front of the jetties.*"

RESULTS WITHIN THE JETTIES.

The next important matter settled by the Board is that relating to results roduced within the jettied channel. The opponents of the jetties, as we have een, started with the prediction that no reliable results would be achieved, and ought to induce the belief that the improvement from time to time in the hannel was not a general one, but that a deepening in one place involved a oaling in another. The report of the present Board disposes very summarily f all such assertions. After quite an elaborate detail of the results produced, ie Board says:

"The maximum bar depth that has been obtained prevailed December , 1877, when it was 23.7 feet. At the date of the latest survey, December th, 1878, it was twenty-three feet. This slightly decreased bar depth by no eans indicates actual retrogression in the progress of results. On the conary, *there has been constant progressive general improvement in the jettied annel, at no time more evident than at present.*

"At the date last named a depth of twenty-four feet, with a channel width three hundred feet, extended down to within two thousand feet of the jetty ds; and the same depth with a channel width of two hundred feet, almost to e very ends. Thence to the same depth outside was a distance of but sixty et, with a navigable channel of twenty-three feet intervening.

"The twenty-five foot channel has nearly the extent of, and not much less idth than the twenty-four foot channel. From its terminus inside to the me depth outside of the bar, there is but an interval of one hundred and nty feet."

PERMANENCY OF THE WORKS.

Another question of interest and importance settled by the Board is that lating to the "permanency of the works." This is of course a matter of reat moment, as it involves the question whether the good results produced an be permanently maintained.

In reference to this matter the Board says:

"*Wave* (or storm) *action* of the sea and *decay* or *destruction by the teredo* of

the willow mattresses are the principal destructive elements to be mentioned; an additional element of deterioration, not peculiar to the location, but supposed to be so prominent as to involve the question of permanence, must also be noticed. The jetties, except the extreme ends and contiguous portions, for about one thousand five hundred feet inward, are so well sheltered by shoals that wave action, except on those portions, has little effect. On the sea ends the effect has been considerable, but mainly superficial, destroying more than once the upper course or courses of mattresses, and washing off and scattering the stones (mostly small) which have been repeatedly applied to the top surface. Wave action is by no means as violent here as in similar exposures on the Atlantic coast. We see no reason to doubt that the thick concrete capping Mr. Eads is now commencing to apply (work having already begun on the upper portions), flanked by enrockments of heavy stones on palmetto-log grillages, overlying the original marginal mattresses, will resist sea action.

"Wood of all kinds, considerably submerged, is sufficiently secure against decay.

"Experience here shows that for about one thousand seven hundred feet inwards from the jetty ends the teredo destroys rapidly all exposed wood (including in this term the willows of the mattresses) lying more than four or five feet below the surface of the water. Evidence enough of its attacks upon piles and willows exists. But the teredo does not attack wood where the free access of sea water is impeded. Those portions of a stick buried in mud or sand, or packed around with mud or sand, are secure. We have no reason to believe that the teredo has penetrated, or can penetrate, far into the interior of the mattress courses; we have pretty good reason to believe that the foundation mattresses are and will remain secure; and probably also the bulk of the interior of the masses of willow-work.

"In what we have said under the head of 'progress' we have given sufficiently full details concerning settlement. It is still very great at the outer ends, though very much less in all those portions more than two or three thousand feet from these ends. That additional superficial applications of stone or concrete will be necessary to the structures we must expect.

"In the ordinary sense of the word permanency, *i. e.*, capability of endurance of destructive forces, the works may be said to possess the attribute to a reasonable degree, for work of the kind thus situated. As regards the outer ends, it is yet early to predict to what extent or how long renewals of height to compensate the still progressing settlement must be resorted to."

MODIFICATION OF THE SPECIFIED DIMENSIONS OF CHANNEL.

Having thus emphatically certified to the complete success of the jetties, the Board proceeds to consider the advisability of modifying the jetty act as regards dimensions of channel and terms of payment. These matters we will notice in their order; and first, as to "dimensions of channel."

An official letter which I addressed to the Board under date of January 4th, A.D. 1879, contained the following urgent request, which is here put in italics:

"With respect to a modification of the dimensions of the channel described in the act, I earnestly hope the Board will state the probable size which the normal discharge of the pass is capable of maintaining between the jetties when

they are fully consolidated and completed, *and that it will also express its views as to the advisability of undertaking to maintain one of greater dimensions, by forcing an increased volume through it.* The results which have been developed thus far by the works seem to me to correspond in a remarkable degree with the effects which were anticipated by the commission of 1874, and to indicate that the maximum capacity of the pass was correctly assumed by the commission. To produce the maximum channel described in the act will, I think, involve the necessity of a central depth throughout the jetties of not less than from thirty-five to forty feet.

"The natural volume of the pass cannot, I am confident, create so great a depth through the jetties, and if it be insisted upon by the United States, it can only be produced by forcing more water through the pass. This will involve, in my opinion, danger to the jetties, and a disturbance of the regimen of the three passes to an extent that can only be known after it is probably too late to remedy the evil."

Having submitted this request for an expression of opinion upon a matter so manifestly important, and so clearly embraced within the duties imposed upon the Board by the act of 1878, I confidently expected a response.

It will be at once apparent to even the casual reader that the question submitted was a vital one. If the safety of the works be endangered, and the destruction of the good results achieved be possible, from forcing an unnatural quantity of water through the pass, thus again placing fetters upon the now free commerce of the river, and if the works now erected are likely to produce a channel sufficient for the present and prospective wants of commerce, it would seem plain that the question is one which should have commended itself to the most careful attention and consideration of the commission. That a twenty-six foot channel is entirely adequate would appear from the fact that the commission of A.D. 1874, instituted by act of Congress, to determine the best method of securing an outlet from the Mississippi River to the Gulf, recommended in its report a resort to the jetty system, claiming that by that system a channel twenty-five or twenty-six feet could be secured.

In this connection it may also be noticed that the president of the present Board (Gen. Barnard), in a minority report on the Fort St. Philip Canal project, dated January 29, 1874,* gave expression to the following opinion:

"With twenty feet at extreme low tide, vessels drawing twenty-two and a half feet could, owing to the softness of the bar, frequent the port of New Orleans, and for mere commercial purposes probably twenty feet draft would be adequate. A draft of twenty-three feet will include eighty-five per cent. of the shipping of the world; and with a draft of but eighteen feet vessels (steamers) can be built of five thousand tons, carrying seventy thousand bushels of corn, or about eleven thousand bales of cotton. It is clear, then, that for commercial purposes a depth of twenty feet on the bars of the passes will suffice to furnish a navigable outlet, and relieve the commerce of the valley from enhanced charges arising from insufficient tonnage in the transports."

A perusal of the report of the present Board will show that it utterly ignores the important question submitted to it by me, and that its recommendations are entirely uninfluenced thereby. It says:

* See Report of the Secretary of War, 1874-'75, vol. ii. part 1, p. 844.

"In view of our recommendation that Mr. Eads be provided with sufficient funds to complete his work according to his own programme, as explained to us, and of his expressed ability to obtain virtually the depths and widths of channel prescribed; and further, as but a short time need elapse before results of completing his plans will be made manifest, this Board thinks it premature to recommend at this time any changes in channel dimensions as required by the contract."

The "expressed ability to obtain the depths and widths of channel prescribed," attributed to me by the Board, may have some light thrown upon it by a reference to a portion of my official letter before quoted. I say in it:

"The natural volume of the pass cannot, I am confident, create so great a depth through the jetties, and if it be insisted upon by the United States, it can only be produced by forcing more water through the pass. This will involve, in my opinion, danger to the jetties, and a disturbance of the regimen of the three passes, to an extent that can only be known after it is probably too late to remedy the evil."

It is passing strange that I should have been so misunderstood by the Board.

A Board composed, as this one was, of several of the most distinguished members of the corps, could not have failed to appreciate the vital importance of a question which not only involves the stability of the jetties, but the regimen, or sensitive adjustment, which nature has established between the different inclinations of the surfaces of the main river and its three chief outlets, and their respective volumes of water, by which adjustment the velocity of current in each channel is so tempered that the floods of the parent stream are discharged through it year after year, without rapid or important alterations in its size, although each flows through a bed formed by the most recent and sensitive deposits of the delta—deposits which are swept away or added to with every abnormal increase or diminution of velocity. The slope or fall per mile of each pass and of the main river is different in each channel, and if the volume flowing in either be increased or diminished, the current velocity must be altered, and it is then no longer adjusted to carry the sediment with which it is charged through such channel without deposit or scour occurring. The result of such disturbance of regimen, therefore, tends at once to produce results which, if unchecked, may lead to the extinction or filling up of the pass with deposits on the one hand, or its continual enlargement on the other, until it may at last discharge the entire volume of the river, and thus destroy the other passes.

That two members of the Board, at least, had settled convictions upon this important question, and that the entire Commission of 1874 fully agreed with them, is evident from the testimony given by these two members (Generals Barnard and Wright), before a committee of the Senate in 1878.

General Barnard, in his testimony, said:

"Question. Suppose the scouring force between the jetties should deepen it from seven to from twenty-three to twenty-four feet; now suppose the scouring force with the present water in it is exhausted at twenty-four feet, would it be safe to turn in any water from the Southwest Pass and Pass à Loutre from the main river, through this South Pass, to add to the scouring, to make it thirty? —Answer. I have no confidence in it; nor was that ever recommended by the Board of 1874. I do not say it cannot be done, but to be safe, I would say it should be a slow process. It would require much labor and great expense. It

would create an additional 'head,' and the results in the case of that kind are not easily foreseen. If done at all, I would advise it to be done very carefully and slowly, and in that way probably more water would be directed in the pass. It would have to increase its own section all the way down in order to carry that water."

General Wright, in answer to the question as to the advisability of forcing more water into South Pass, in his testimony, said :

"The Commission of 1874, which got up the original plan of the jetties, discussed that matter at great length, and it was, I think I may say, the unanimous opinion of the members that the size of the pass could not be interfered with ; that what we wanted was that the regimen of the pass should not be disturbed ; and to that end there is put into the estimates a certain amount, I don't remember whether specifically or not, though I think it was, to prevent any enlargement of the pass at all."

In the face of this record further comment is unnecessary.

MODIFICATION OF TERMS OF PAYMENT.

We next come to consider the recommendations of the Board as to the advisability of a modification of the act of A.D. 1875, as regards "terms of payment." In its consideration of this question, the Commission does not exhibit that breadth of view which would be expected from officers of such high rank and character. The Board approaches the matter from a most unfortunate standpoint. It adverts to the fact that Congress did not leave "the execution of the work to its own agents." It will be unnecessary now to discuss the question as to whether government engineers should have a monopoly of government work, and the civil engineers of the country be excluded from all participation therein, and this regardless of all considerations, whether in the saving of money to the Government or otherwise. This matter seems evidently to have presented itself to the mind of the Board, and no doubt unconsciously warped its judgment and contracted its views. How far it did so, can only be determined by a careful consideration of the report. Now, what facts do the board find ? 1. That the works are permanent ; 2. That great and good results have been produced thereby ; 3. That $350,000 will substantially complete the works ; and, 4. That the works, when completed, will probably produce a channel which can be maintained of at least twenty-five or twenty-six feet in depth. In regard to the amount which will be necessary to complete the works, the Board says :

"Mr. Eads estimates the cost of doing the work thus summarily indicated at $349,641.

"The Board have carefully gone over the details of this estimate, and believe that it is substantially correct. They differ from Mr. Eads in some minor items of cost, but these differences are amply covered by the $58,273 allowed for contingencies.

"The Board is therefore of the opinion that the work indicated by Mr. Eads can probably be done for his estimate, provided no extraordinary contingencies intervene."

The Commission of 1874 estimated the cost of the works at the sum of $5,342,110. I agreed, however, to do the work for $5,250,000, thus saving to the

Government $92,110 in construction. And I agreed to maintain the works for twenty years for $100,000 per annum (which maintenance the Commission had estimated at $130,000 per annum), thus saving $600,000 more. It appears, then, that $5,250,000 was a low estimate for the cost of the work. The Board (as we have seen) says $350,000 will complete the work; and it admits that only $1,686,066 has been paid on it up to this time.

The account, therefore, from the Board's own showing, stands thus:

Price to be paid for the works	$5,250,000
Paid on account to date	1,686,066
Amount unpaid	3,563,934
Required to complete the works	350,000
Surplus in the hands of the United States	$3,213,934

Reference might here again be made to my letter to the Board, from which I quote the following:

"But if the progress made by us in producing stipulated depths of channel be alone taken as the only basis for determining the proportion of the work that has thus far been completed (although such method of estimating it would seem manifestly unfair), it can be shown that the pay received falls much below what it should be, even under such ruling.

"For instance, we were to deepen the bar from eight feet to thirty feet, being a total deepening of twenty-two feet, of which twenty-two feet we have already accomplished fifteen feet, having at present a channel depth of twenty-three feet. This is equal to fifteen twenty-seconds, or nearly sixty-eight per cent. of the total depth.

Sixty-eight per cent. of the price for the completed work is	$3,570,000
Paid by the Government (to Jan. 1st)	1,600,000
	1,970,000
Less ten per cent. reservation	197,000
Leaving unpaid and already earned	$1,773,000

"If this sum were authorized to be paid at once by the Government, it would still retain $1,877,000, or $877,000 to complete the works, and $1,000,000 reserved to be paid in ten and twenty years. I will add that, if this total sum were at once paid me, it would not suffice to discharge all the debts created by me in the construction of the works."

Surely the retention by the Government of the sum of $1,877,000 would afford it ample security to cover any exigency which might arise. The conclusions of the Board upon this subject we will notice hereafter. Reference may here be made, however, to a suggestion of the Board touching the matter of future expenditures upon work at the sea ends of the jetties. It says:

"The jetties may be considered as fairly permanent, except the outer ends for a distance of about one thousand five hundred feet. Here the chief difficulty is due to the softness of the bottom on which the jetties rest. Experience

indicates that they will continue to settle, and will therefore require to be raised from time to time. When this subsidence will cease it is now impossible to predict. All the other works may be considered as fairly permanent, or can be made so. What repairs will be needed on them from time to time will be moderate in amount and easily made."

If, indeed, it be true that the sea ends of the jetties will settle, and it will become necessary to raise them from time to time, such work can readily be done without reference to the sum of $5,250,000 to be paid for the work. The act of A.D. 1875 (jetty act) reserves one million of the price, and $100,000 per annum as an independent fund for maintenance, which is sufficiently ample to cover all such contingencies.

PROBABLE RESULTS.

We now come to consider the question "what depths of channel will the works produce?" In regard to this the Board says:

"The foregoing considerations and the facts already stated under the head of results actually observed in the progress of channel development during the last twelve months, induce us to think that if the jetties were well consolidated and raised sufficiently high to prevent leakage and overflow, a considerable increase of navigable depth would result. We cannot state that, in our opinion it is a 'probable result' that the depth of thirty feet will be attained, as assumed by Mr. Eads. What the limit will be cannot be positively announced. That it may attain a depth of twenty-five or twenty-six feet is all we can venture to expect as a depth which shall permanently maintain itself; and as past experience shows annual fluctuations amounting to about two feet, a permanent channel of twenty-five or twenty-six feet will require an occasional channel of twenty-seven or twenty-eight feet."

RECOMMENDATIONS OF THE BOARD.

Having thus given the facts found and submitted by the Board, we come to consider its recommendations. These are, in brief, as follows: 1, That $250,000 of the twenty-six foot payment be advanced to me, to be expended under conditions similar to those imposed by the third section of the act of June 19, A.D. 1878; and 2 (in the language of the Board), "As every additional foot in depth of channel is a benefit to commerce, we would suggest the advisability of a change in the terms of payment in the original act, so as to allow of payments for each additional foot gained instead of for every two feet, the channels and payments to be as shown in the following table:

Present System.			System Recommended.		
Channel.	Pay'ts.	Payments for 12 months' maintenance.	Channel.	Pay'ts.	Payments for 12 months' maintenance.
28'x350'	500,000	250,000 with 6 per cent. interest.	27'x825'	250,000	125,000 with 6 per cent. interest.
			28'x350'	250,000	125,000 with 6 per cent. interest.
30'x350'	500,000	500,000 with 5 per cent. interest.	29'x350'	250,000	250,000 with 5 per cent. interest.
			30'x350'	250,000	250,000 with 5 per cent. interest."

In the face of the great results accomplished and about to be accomplished, and with less than one-third of the price of the works paid, the Board recommends no action whatever by Congress which would really afford me the relief which my necessities demand. The report is rich in expressions of approval of the work—poor only in its recommendations. Of what avail to me would be the advance of $250,000, hampered by the condition that it be expended only on the works? Would it serve to relieve me from the mountain of debt which I bear? Would it pay, even to a small extent, the contractors whom I have employed, and who have devoted their whole fortunes and years of labor to this great work? The liberality of this recommendation of the Board is only equaled by that of its second recommendation, which, in plain English, may be stated thus: "The works will not, we believe, produce a greater depth of channel than twenty-six feet. We recommend that for every additional foot *over* twenty-six feet secured, Mr. Eads be paid the following sums of money."

Again I call attention to the fact that the Board of A.D. 1874 (of which one of the present Board was the president), recommended the improvement of the South Pass. They said in substance: This work will cost $5,342,110; it will secure a channel twenty-five or twenty-six feet in depth. This is a sufficient channel to accommodate the present and prospective wants of commerce, and the work should be done. The present Board (in effect) says: Mr. Eads has done the work contemplated by the Board of A.D. 1874; he has secured twenty-three feet of channel depth; the completion of the works, which are of a permanent character, will cost $350.000, and a channel will then be produced of twenty-six feet, which can be maintained; for this work Mr. Eads has only thus far received from the Government $1,686,066, and, with $3,563,934 of the agreed price still unpaid in the hands of the Government, we are only willing to recommend that $250.000 more, hampered with the condition that every dollar shall be expended on the work, shall be appropriated by Congress, and provision be made that he shall receive further payments when he obtains depths which we do not believe he ever can secure.

The Board, in its report, uses the following language:

"But it should be remarked that a channel of less depth than eighteen

feet at South Pass was not necessary. * * * * The useful result accomplished is, therefore, a channel from eighteen feet to twenty-three feet." In this connection the Board might have added that a permanent channel eighteen feet in depth was worth to the Government $250,000 per annum, as it cost about that amount to maintain the uncertain channel at Southwest Pass.

Particular attention is called to the following paragraph in the report:

"The Board of 1874, instituted by act of Congress to determine the best method to secure an outlet from the Mississippi River to the gulf, either by a canal or by the improvement of one of its natural outlets, reported in favor of improvement of the South Pass at an estimated cost of $5,342,110, declaring that while its estimate was designed to cover every possible contingency of cost, it was believed the work could be done for a much less sum. No reason is known why Congress, which adopted this recommendation, should not have left the execution of the work to its own agents, except that the present contractor, Mr. James B. Eads, offered to accomplish the results contemplated by the Board without payment unless those results were secured. It would seem, therefore, that this proposition of payments for results only influenced Congress to award the contract to Mr. Eads, instead of leaving the execution of the work to its usual agents. Taking this principle of no payments except for results as the motive which governed Congress in awarding the contract to Mr. Eads, we are prepared to consider his claims to aid beyond what the original contract gives him, and what the supplemental act of June 19, 1878, advances to him."

This paragraph conveys the plain inference that I have been simply executing a system of improvements originally designed and recommended by the Commission of 1874, and that the construction of the works was not put in the hands of the Engineer Corps of the Army by Congress simply because I promised certain specified results on pain of non-payment. This inference is fully sustained by the conclusions of the Board and its recommendations. I am thus not only denied the right to pecuniary relief by the deductions which the Board has drawn from its premises, but the premises themselves deprive me of any consideration in connection with my appeal, of the important fact, that it was I, and not the engineers of the army, who initiated and planned the improvement which has proved so successful.

This statement of the Board and its unfair conclusions therefore compel me, in self-defense, to state that I urged this plan of improvement *as the only proper one*, upon the attention of a large number of the members of the Forty-third Congress, in May of 1873, during their visit to the mouth of the river, and that in the winter following I made a formal proposition to Congress to deepen the mouth of the Southwest Pass by the jetty system, *and offered to guarantee* its complete success, *before* any member of the Corps of Engineers (so far as I can learn) had ever expressed officially or publicly any *preference whatever* for this method of improving the mouth of the Mississippi over that of a canal, and long before the Commission of 1874 was even thought of.* In-

* The first appropriation for improving the mouth of the river was made 42 years ago. The plan of dredging with buckets was recommended, and the plan was approved by a Board of United States Engineers. In 1852, another appropriation was made, and a Board composed of Captain Latimer, of the Navy, and Major Chase, General Barnard, and General Beauregard was appointed. This Board recommended, *first*, the process of stirring up the bottom should

deed, the very creation of the Commission was the result of my proposal, and the opposition it evoked from some of the prominent engineers of the army. General Barnard afterwards,* and the Commission after him, recommended its application to the South Pass, which location required the reduction of a shoal at the head of the pass, that has since been admitted by engineers generally to have been a problem of greater difficulty than that at the mouth. General Barnard and the Commission simply differed with me in the selection of the pass for the application of the jetty system, and there has been nothing in the results produced, or in my studies of the subject, to alter my belief that a larger and deeper channel could have been secured at an earlier date at the Southwest Pass, and one no less permanent, than the one which has been obtained at the South Pass.

So far as the plans of construction and location of the various works are concerned at South Pass, they are my own, and were not furnished or planned by the Commission. The report of the Commission and the lesser cost of improving South Pass caused the Senate to disagree with the House, which, notwithstanding the report, had voted almost unanimously to apply the proposed system to the larger pass.

The unusual severity of those provisions of the jetty act, by which an almost entire completion of the work was really required for a total payment of less than one-third of the agreed price, can only be attributed to the hostility evinced by some of the members of the Engineer Corps of the army. Their arguments against the plan and their determination that this great work should not be intrusted to me, gave birth to all kinds of predictions of evil and failure. Their antagonism naturally enough alarmed Congress, and resulted, first, in the enactment of the severe provisions referred to; and, second, in requiring me to accept the South instead of the Southwest Pass. The bill as it passed the House provided for the improvement of the Southwest Pass. In the closing hours of the session, however, the Senate Committee, as advised by the Commission, substituted the South Pass; but, against my own protestation and *without the advice of experts*, it insisted on my agreeing to produce at this little pass, depths and widths of channel similar to those I had proposed for a pass four times as large, or else see the execution of my project put into the hands of its opposers.

be tried; *second*, if this failed, dredging by buckets should be tried; *third*, if both those modes failed, parallel jetties should be constructed "at the mouth of *Southwest Pass*, to be extended into the gulf annually, as experience should show necessary;" *fourth*, should it then be needed, lateral outlets should be closed. *Finally*, should all these methods fail, *a ship canal* might be resorted to. See Humphreys and Abbott's Report, page 486.

* General Barnard, in his minority report on the Fort St. Philip Canal, dated 29th January, 1874, discusses, *first*, the method of dredging or stirring up the bottom, and, *second*, that of jetties. With respect to dredging, and as a reason for *further consideration* and study of the means to be finally selected for surmounting the difficulties at the mouth of the river, he says: "By reference to the best authority, I have proved the adequacy of dredging operations on the bar by well-tested means; but I think there is yet room for improvement, and especially in diminishing cost." He further says of dredging, that the attainment of 20 feet depth on the bar has by no means been established to be the maximum, and adds: "As to that depth, however, we have the strongest assurances." He discusses the jetty method of improvement with great ability, but says: "The question submitted, however, is not so much to recommend its trial (of the jetty system) as to recommend its *consideration* and that scrutiny and survey on which alone estimates can be based."

In March, 1871, the Secretary of War was requested to cause an examination and survey, with plans and estimates of cost, to be made for a ship canal to connect the river with the gulf, and to report upon the feasibility of the same. About three years later (February 4, 1874) a Board consisting of seven army engineer officers reported in favor of its construction, General Barnard, its president, alone dissenting. The majority of that Board and the Chief of Engineers took strong ground against the jetties, and the energy with which their opinions were maintained resulted in the passage of a bill in the House of Representatives in June, 1874, appropriating $8,000,000 with which to *commence* the construction of the canal, the cost of which was estimated at $13,000,000.* The Senate Committee rejected the canal bill, and introduced a bill to create the Commission referred to by the Board as the Commission of 1874, which Commission did not report in favor of applying the jetty system to the South Pass until January 13th, 1875.

I think the members of the Forty-third Congress will dissent from the inference sought to be created by the Board, namely, that the method of improvement adopted by that Congress was originated by the Commission of 1874, and that but for my proposal the engineers of the army would have been intrusted with the building of the jetties; for the facts show that the Commission of 1874 would not have been created but for my proposal, and that if I had not made it, and urged the jetty system with all the ability I could command, the "usual agents of the government," instead of being intrusted with this work, would, in all probability, now be digging in the sickly marshes of Louisiana the canal recommended by a prior Commission.

Of that stupendous project, General Barnard, when advocating "an open river mouth," said, "It would be a rash confidence that would anticipate a completed Fort St. Philip Canal earlier than 1884."

From these facts it is evident that if it had not been for my proposition to deepen the mouth of the Mississippi River by the jetty system, the commerce of the vast empire which constitutes its valley, would to-day, and for years to come, be fretted and hampered by the bars at the mouth of the river, or be compelled to seek expensive and unnatural routes to the seaboard. Further comment is unnecessary.

It remains to be seen whether an American Congress is prepared to put the stamp of condemnation upon individual enterprise, and decline to act with justice and liberality toward one, who, in the face of unprecedented difficulties, has secured to the Valley of the Mississippi, and to the whole country, a deep and permanent outlet from the river to the sea.

* See report of the Secretary of War, 1874, 1875, vol. ii, part 1, page 866.

APPENDIX XX.

(See page 202.)

ACT OF CONGRESS,

Approved March 3, 1879.

BEING PART OF THE

RIVER AND HARBOR BILL

OF THAT DATE.

THAT the fourth and succeeding sections of an act entitled "An act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," approved March 3d, anno Domini eighteen hundred and seventy-five, authorizing James B. Eads and his associates to create and permanently maintain a wide and deep channel between the South Pass of the Mississippi River and the Gulf of Mexico, be and they are hereby amended so as to provide, in lieu of the payments therein provided, that payments to said Eads or his legal representatives shall be made as follows, namely:

The Secretary of War is hereby authorized and directed to draw his warrant upon the Secretary of the Treasury of the United States, in favor of said James B. Eads or his legal representatives, for the sum of seven hundred and fifty thousand dollars, which said sum is hereby appropriated; and the Secretary of the Treasury is hereby authorized and directed to pay to said Eads or his legal representatives, out of any money in the treasury not otherwise appropriated, the sum for which said warrant is drawn.

When a channel shall have been obtained by the action of the jetties and auxiliary works authorized by said act, twenty-five feet in depth, and not less than two hundred feet in width at the bottom, through the said jetties, there shall be paid five hundred thousand dollars.

When a channel shall have been obtained through the jetties twenty-six

feet in depth, and not less than two hundred feet in width at the bottom, there shall be paid five hundred thousand dollars.

When a channel thirty feet in depth, without regard to width, shall have been obtained through the jetties, there shall be paid five hundred thousand dollars; and the one million dollars provided by the hereinbefore-recited act to be paid by the United States in ten and twenty years shall be earned by said Eads and his associates, and the same, with interest, shall be paid to said Eads or his legal representatives, at the times and in the manner provided by said act.

The one hundred thousand dollars per annum provided by said recited act to be paid to said Eads and his associates during a period of twenty years, shall be paid at the times and in the manner therein provided, upon the maintenance by said Eads and his associates of a channel through the jetties twenty-six feet in depth, not less than two hundred feet in width at the bottom, and having through it a central depth of thirty feet, without regard to width.

Nothing herein contained shall be so construed as to repeal or in any wise affect the provisions of the amendatory act, approved June 19, anno Domini eighteen hundred and seventy-eight, by which said Eads is entitled to receive certain moneys to pay for materials furnished, labor done, and expenditures incurred in the construction of the work at the mouth of the Mississippi River; and the whole of the hereinbefore-recited act, approved March 3d, anno Domini eighteen hundred and seventy-five, except as the same is hereby expressly modified or amended, or has by act heretofore passed been modified or amended, shall be and remain in full force, and have the same effect as if this act had not been passed.

APPENDIX XXI.

(See page 220.)

TABLE OF COMPARISON

OF SCOUR AND DEPOSIT IN 37 SUBDIVISIONS, CONTAINING ABOUT
MILES, OR 178.38 ACRES, IMMEDIATELY SEAWARD OF THE EN

SOUTH PASS JETTIES,

(See Plate 23, facing page 220,)

BETWEEN THE DATES OF MAY, 1875, AND DECEMBER, 1879,
COMPARATIVE CHART, PLATE 23.

Number of subdivisions.	Area of subdivisions in square feet.	Mean depths in subdivisions in feet.		Scour in subdivisions in cub. yds.	Deposit in subdivisions in cub. yds.
		1875.	1879.	1875 to 1879.	1875 to 1879.
1	500,000	21.5	26.1	85,185	
2	500,000	33.2	31.6		29,629
3	500,000	33.9	37.6	68,519	
4	500,000	41.1	42.0	16,667	
5	500,000	47.8	45.7		38,889
6	50,000	18.3	17.8		926
7	100,000	36.9	30.7		22,963
8	150,000	31.2	37.2	33,333	
9	200,000	39.0	35.0		29,629
10	250,000	48.3	48.2		926
11	50,000	24.6	24.9	556	
12	100,000	30.3	34.9	17,037	
13	150,000	33.2	40.2	38,889	
14	200,000	38.9	39.8	6,667	
15	250,000	52.3	46.8		50,926
16	100,000	15.4	14.7		2,592
17	100,000	36.6	30.1		24,074
18	200,000	36.0	37.4	10,370	
19	250,000	37.6	37.5		926
20	100,000	23.6	27.1	12,963	
21	100,000	28.8	35.1	23,333	
22	200,000	32.7	38.5	42,963	
23	250,000	45.7	40.4		49,074
24	100,000	16.0	13.0		11,111
	5,400,000			356,482	261,665

APPENDIX XXI.—(*continued*).

Area of subdivisions in square feet.	Mean depths in subdivisions in feet.		Scour in subdivisions in cub. yds.	Deposit in subdivisions in cub. yds.	Number of soundings in subdivisions.	
	1875.	1879.	1875 to 1879.	1875 to 1879.	1875	1879.
5,400,000			356,482	261,665	241	843
200,000	34.6	28.8		42,963	10	24
250,000	37.7	36.3		12,963	10	28
60,000	31.3	34.0	6,000		2	14
100,000	28.0	30.4	8,889		4	18
200,000	31.5	36.9	40,000		7	24
250,000	38.9	41.0	19,444		11	26
60,000	41.3	42.3	2,222		2	10
125,000	23.0	15.6		34,259	7	26
250,000	38.7	32.5		57,407	7	30
250,000	28.5	33.3	44,445		14	25
125,000	31.3	34.1	12,963		10	17
250,000	39.9	39.5		3,704	8	26
250,000	44.6	42.6		18,519	4	25
7,770,000			490,445	431,480	337	1136

ess of scour over deposit over whole area of 7,770,000 square feet, 58,963 ards.

KEY TO COMBINATIONS.

Combination A contains subdivisions 1–5 inclusive.
" B " 1–15 "
" C " 1–23 "
" D " 1–31 "
" E " 1–37 "

Area of combinations in square feet.	Mean gain in depth on combinations from 1875 to 1879, in feet.	Mean loss in depth on combinations from 1875 to 1879, in feet.	Scour in combinations from 1875 to 1879, in cub. yds.	Deposit in combinations from 1875 to 1879, in cub. yds.	Number of soundings in combinations.	
					1875.	1879.
2,500,000	1.10		101,852		114	340
4,000,000	0.63		92,963		171	612
5,300,000	0.54		105,926		237	825
6,520,000	0.52		125,444		287	987
7,770,000	0.20		58,965		337	1136

APPENDIX XXII.

(See page 221.)

No. 1.—TABLE SHOWING CHANGES IN GULF BOTTOM BEYOND THE JETTIES.

(See Plate 24, facing page 230.)

TABLE OF CHANGES IN DEPTHS, WITH SCOUR AND FILL IN CUBIC YARDS, COMPARING SUBDIVISIONS OF CAPT. BROWN'S FAN-SHAPED AREA, Nos. 7 TO 19 INCLUSIVE, 1876 AND 1879. (*See* Annual Report of Capt. M. R. Brown, June 30, 1879, page 36.)

No. of subdivision.	Mean depths, feet.		Area, square feet.	Cubic yards of water overlying subdivisions.		Scour, cub. yds.	Fill, cub. yds.	No. of sounding-lines, 1876.	No. of sounding-lines, 1879.
	1876.	1879.		1876.	1879.				
7	63.63	62.66	3,146,568	7,415,403	7,303,062		112,341	19	90
8	58.40	58.30	1,177,965	2,547,905	2,543,532		4,373	15	33
9	53.78	56.58	1,911,590	3,807,800	4,005,839	198,039		46	30
10	47.93	47.70	1,804,280	3,203,170	3,187,621		15,549	59	35
11	52.48	54.54	1,910,900	3,714,389	3,860,303	145,914		56	43
12	50.56	51.05	1,177,965	2,205,950	2,227,400	21,450		40	33
13	36.80	40.35	2,664,385	3,631,752	3,982,775	351,023		66	72
14	31.46	34.73	354,931	413,612	456,546	42,934		14	13
15	35.20	40.26	196,900	256,699	293,599	36,900		15	10
16	33.37	39.01	395,320	488,689	571,281	82,592		53	11
17	29.28	33.16	1,658,310	1,798,376	2,036,957	238,581		271	55
18	31.44	35.92	390,660	454,959	519,838	64,879		36	14
19	37.08	39.47	195,900	269,090	286,413	17,323		12	4
	Totals.....		16,985,674	30,204,794	31,274,881	1,202,350	132,263		

$$\frac{30,204,794 \text{ cubic yards}}{16,985,674 \text{ square feet}} = 48.01, \text{ mean depth in 1876.}$$

$$\frac{31,274,881 \text{ cubic yards}}{16,985,674 \text{ square feet}} = 49.71, \text{ mean depth in 1879.}$$

Average increase of depth over whole area.... 1.70 feet.
Excess of scour over deposit " " 1,070,087 cub. yds.

APPENDIX XXII.

I.—TABLE COMPARING U. S. COAST SURVEY OF 1875 WITH SURVEY OF U. S. ENGINEERS OF 1879, USING SUBDIVISIONS OF CAPT. BROWN'S FAN-SHAPED AREA.

Mean depths, feet.		Area, square feet.	Cubic yards of water.		Scour, cub. yds.	Fill, cub. yds.	No. of soundings, 1875.	No. of soundings, 1879.
1875.	1879.		1875.	1879.				
36.52	40.26	196,900	266,658	293,599	26,941		17	10
35.36	39.01	395,320	517,722	571,281	53,559		15	11
34.32	33.16	1,658,310	2,108,044	2,036,957		71,087	53	55
34.36	35.92	390,660	497,151	519,838	22,687		15	14
34.65	39.47	195,900	251,405	286,413	35,008		7	4
Totals.....		2,837,090	3,640,980	3,708,088	138,195	71,087		

$$\frac{3,640,080 \text{ cubic yards}}{2,837,090 \text{ square feet}} = 34.65, \text{ mean depth in 1875.}$$

$$\frac{3,708,088 \text{ cubic yards}}{2,837,090 \text{ square feet}} = 35.28, \text{ mean depth in 1879.}$$

Average increase of depth over whole area.... 0.63 feet.
Excess of scour over deposit.....67,108 cub. yds.

APPENDIX XXIII.

(See page 228.)

RATE OF SUBSIDENCE OF CONCRETE BLOCKS. EXPRESSED IN DECIMALS OF FOOT.

EAST JETTY.

Station.	Subsidence in *first* 5 months after 1st month.	Subsidence in next 5 months.	Total subsidence in 10 months.
104	.107	.090	.197
105	.116	.116	.232
106	.196	.096	.292
107	.338	.201	.539
108	.193	.313	.506
109	.300	.233	.433
110	.283	.312	.595
111	.261	.206	.467
112	.281	.226	.507
113	.283	.330	.613
114	.256	.278	.534
115	.228	.241	.469
116	.410	.227	.637
Average.....	.243	.220	.463

WEST JETTY.

Station.	Subsidence in 4 months, after 1st month.	Subsidence in next 5 months.	Total subsidence in 9 months.
103	.165	.028	.193
104	.090	.058	.148
105	.171	.028	.199
106	.256	.045	.301
107	.247	.041	.288
108	.190	.040	.230
109	.340	.180	.520
110	.437	.191	.628
111	.371	.102	.473
112	.314	.108	.422
Average.....	.258	.082	.340

Average subsidence on both jetties..... .401

Rate of subsidence per month..... 0.042 feet, or $\frac{1}{2}$ inch.

APPENDIX XXIV.

(See page 235.)

RECORD OF NAVIGATION.

Sailing Vessels in and out over South Pass Bar.

Draft in feet.	May, 1875, to July, 1876.	July, 1876, to July, 1877.	July, 1877, to July, 1878.	July, 1878, to July, 1879.	July, 1879, to May 18, 80.	Total.
10 to 18	19	307	922	923	955	3126
18 " 20	..	20	109	89	130	348
20 " 22	..	...	32	15	40	87
22 " 24	..	...	...	4	5	9
Total Number..	19	327	1063	1031	1130	3570

Steamships in and out over South Pass Bar.

10 to 20	29	153	576	653	704	2115
20 " 24	..	10	11	81	134	236
24 " 25	..	...	...	...	2	2
Total Number..	29	163	587	734	840	2353

Total steamships and sailing vessels in five years..... 5923

APPENDIX XXV.

(See page 240.)

EMPLOYEES DESERVING HONORABLE MENTION.

R. S. Elliott, Private Secretary and Secretary South Pass Jetty Co.
Wm. S. Nelson,* Captain of dredge-boat *G. W. R. Bayley.*
W. L. Wright, Chief Clerk and Paymaster at Port Eads.
W. J. Karner, Cashier and Purchasing Agent in charge of New Orleans office and Secretary in compilation of History of Jetties.
Henry Cory, Superintendent of mattress work.
Thomas T. Rubey, Captain of steamer *Grafton.*
James Keefe, Master Mechanic and Superintendent of Construction.
Chauncey Hoadley, Foreman of Mattress Placing and Sinking.
Wm. Tinsley,* Foreman of Mattress Construction.
John Holland,* " "
H. C. Blanchard,* " "
Geo. L. Mitchell, Pile-driver and Concrete Foreman.
Joseph Greppin, Master Machinist.
M. C. Tully, Foreman and Mate of dredge-boat *Bayley.*
Peter McGee, Pile-driver Foreman.
John McGee, " "
Wm. Faber, Blacksmith.
J. T. Heuston, Leadsman.
John Frasier, Captain of Tug *Brearly.*
Geo. W. Adams, Captain of Tug *Ella Andrews* and dredge-boat *Bayley.*
Spencer P. Rous,* Chief Engineer of steamer *Grafton.*
F. C. Welschhans, Telegraph Operator.
W. J. Mathews, " "
A. W. Wire, " "
J. H. Stockley, Resident Physician.

* Deceased.

APPENDIX XXVI.

GEOGRAPHICAL, HYDROMETRICAL, METEOROLOGICAL,

I. Geographical.

Location of Jetties.

Longitude 89 deg. 9 min. west from Greenwich.
Latitude 29 deg. 0 min. north.

II. Hydrometrical.

a. Fluvial.

Location of Gauge.	Distance from Gulf.	Range of River.	
Carrollton	115 miles.	17.40 feet.	From — 1.70 on gauge to + 15.70.
Head of Passes..	12½ "	2.50 "	
S. Pass Light-house.....	2½ "	0.40 "	

b. Tidal.

Character of tides, diurnal (single day type). Mean rise and fall, 14 inches. Extreme range (from storms and other causes), 5 feet. Tidal current approaching delta, maximum velocity, 1.5 feet per second. Reverse currents in South Pass at Port Eads, with Carrollton gauge at + 0.70, tide rising during observations 1.48 feet, and at a depth below surface of 18 feet, average velocity, 0.82 feet per sec.; maximum velocity, 1.06 feet per second. "Average flood-tide" of U. S. Engineers at South Pass Lighthouse (datum plane for measurements of channel depth), 1.8 feet above mean low water of U. S. Coast Survey, and 0.2 feet below datum plane at head of pass.

III. Meteorological.

a. Winds.

Direction, chiefly between N. E. and S. E. Maximum velocity observed, 61 miles per hour. Average velocity in seven storms

at Southwest Pass, 35¼ miles per hour ; raised tides above normal level, an average height of 2.34 feet.

b. Thermometrical.

Average range during the year, from 35 degrees Fahrenheit to 93 degrees. Average height in summer, 85 degrees. Average height in winter, 65 degrees.

c. Rainfall. (1877–1879) Average, 54.45 inches per annum.

INDEX.

leeward bank, 78.
er of, in Miss. Valley, 2.
ession, anniversary of, 96; text
55; amendatory, text of, March
68, 369.
Gen. W., placed in charge, 188.
wealth of, land-locked, 6; bene-
96.
Gen. B. S., member of Advisory
2; on Commission of 1876, 142.
urve of, 74; East Jetty, 75.
ines, conditions of contract of,
raphical, 72; jetties indebted to,

den, 87.
ns, Congress must make, for pay-
55.
he, description of, 4.
ads's, in concession, 67.
ie, schooner, 96.
od Side," discussion of, at head
301.
l, head of passes, 113.

harged at Port Eads, 210; where
210.
t. Louis to Eads, 66.
led in 1859, 7; rate of advance,
al depths on, 13; slopes of, 13;
ns of, 15; will not reform soon,
ry of formation by Gen. Humph-
formed by same process as at
ta rivers, 45; cannot be deepened
feet by stirring process, 60; ad-
discussed by Commission of 1875,
outh Pass, least depth on, 1875,
rmation hastened by delay, 81;
of, prophesied by opponents, 198;
inspecting officer disproves ad-
198; difference between S. and
ss, 231; formation of, described
1875, 255; advance of, calculated,
ldity of, shown by pile-driving,
ance of, discussed by Board 1879,
ogression of, proved, 357.
ne of, changes in, 102; Schmidt's
103; report on, by Board of 1878,
ults of jetties upon, 216; changes
rated by curves, 217, 218; changes
rated by movement of material,
sults on, shown by fan-shaped
; shoals and lumps on, reduced
nt, 234; changes in, shown by
70-373.
n. J. G., president of Board of
; makes minority report, 22;
of Advisory Board, 92; on Com-
of 1876, 142; on Commission of 1877, 165; letter of Eads referred to by, 170; on Board of 1878, 191; his relations to jetty project discussed, 197; explains reasons for minority report, 198; statement of, before Senate Committee 1878, 200; president Board 1874, 243; minority report of, 247–249; reports on Eads's letter, May 13, 1878, 313; president Board of 1879, 335.

Barges, size of, 77; to sink mattresses, 79; capacity for stone, 209; fleets of, for grain, 237.

Basin, caused by wing dams, 152.

Basins, drainage, description of, 3.

Bay, Garden Island, 70.

Bayley, G. W. R., early advocate of jetty system, 54; journal of, 74; general direction of affairs given to, 81; death and memoir of, 146; concurs in Corthell's statement, 282.

Beauregard, Gen. G. T., member of Board of 1852, 20; opinion of, on jetties and canal, 247.

Béton, blocks of, for consolidating jetties, 188.

Bill for improvement of S. Pass passed by Congress, 66.

Board of 1852, recommendations of, 17–20; of 1874, majority favors ship canal, 21; advisory, meets, 92; opinion of, 93; of 1878, 191; report of, 192–194; report reviewed by Eads, 194–200; of 1874, 243–250; of 1875, 251–260; advisory, report of, 266–274; report of, Jan. 23, 1879, 335–355; reviewed by Eads, 357–367.

Bonds or money in payment, 265.

Bridge, St. Louis, constructed by Andrews, 72.

Bridle rope for mattress, 78.

Briquettes for testing cement described, 204.

Brown, Capt. M. R., surveys channel, May, 1876, 100; his fan-shaped area, 220; complimentary, 240.

Buisson, Benj., plans ship canal, 1832, 19.

Bussey, Gen. Cyrus, extracts from letter of, on commercial benefits, 286.

Cameron, J. D., Secretary of War, complies with requests of Eads, 104–106; instructs Commission, 1876, 143, 299.

Canal, Fort St. Philip, history of project of, 19–23; bill of, passed House of Rep., 47; bill of, did not pass Senate, 48; Commission discuss location of, and give estimate, 60; report of Board, 1874, 243; locations discussed by Board, 1875, 253; estimate of, 254.

Car, dumping, for concrete, 190.

Carrollton gauge, record of, 172, curve of, 217; range of river on, 377.
Caving of banks explained, 30.
Cement, specifications for, 204; Saylor's American Portland, described, 204; light weight, strength of, 205; strength and hardness of, 206.
Certificates used for pay-rolls, 156.
Chamber of Commerce, N. O. recommend ship canal, 20; favors canal and opposes jetties, 37.
Channels, necessary to be obtained quickly, 81; development of, 94; illustrated, 94; table of depths of, 95; materials removed from, 95; development of, 1876, 142; 20 feet by 200 feet, 142; jetty, contracted, 146; 20 feet reported Dec. 27, 1876, 146; payment of, delayed, 146; remarkable enlargement of, 150; condition of, July, 1877, 158; 22 feet by 200 feet obtained, 165; changes in head of pass, 179; results produced, 192; dimensions of, should have been considered by Board, 199; S. Pass and S. W. Pass, in cost compared by Eads, 1878, 202; results in, 211; 25 feet by 200 feet obtained, 211; 30 feet obtained, 212; changes in, illustrated in Appendix 6, and 17, 212; fluctuations of, reasons for, 212; relation of, to construction work, 213; total amount of material removed from, 213; artificial deepening of, not permanent, 214; material removed from, plotted, 217; at head of pass, 30 feet, 223; general results in, 228; process of formation of, 236; full section of, not yet obtained, 229; opinion of maximum size by Eads and Hartley, 229; greater dimensions probable, 230; results in, shown by models, 234; terms and payments of in grant, 262; natural causes of formation given, 273; table of depths in, 276; contour lines of, 277; table of depths of, 333, 334; results in, stated by Board, 1879, 346-348; probable, 348, 350; progressive improvement of, 357; dimensions of, discussed, 358, 361.
Chase, Maj. W. H., plan of, for ship canal, 19.
Chief of Engineers, U. S. A., instructed by Secretary of War to discontinue surveys, 106.
Coast Survey, U. S., just preceded us, 71; Supt. of, instructed by act to make survey, 71, 264.
Commerce released by jetties, 1; of Miss. Valley, 3; benefits to, 235, 236, 237.
Commission of January 14, 1875, names of, 49; decide to visit rivers of Europe, 49; report of, 1875, 60; on head of passes, 1876, 143-145; of 1877, 165; advisory, report of, 266, 274; of 1876, report of, 297; of May 13, 1878, 313-319.
Committee, U. S. Senate, unwilling to improve S. W. Pass, 65.
Company, S. Pass Jetty, formed to furnish additional means, 68; relation to enterprise, 68; commended, 239.
Comstock, Gen. C. B., declines to give information, 100; opinion of, on head of pass channel, 142.
Concrete, preparations for, 188; described, 189; proportions of ingredients, 190; extent of, and size of blocks, 202; materials for, described, 203; generated wave forces, 206; record of levels on, 228; rate of subsidence of, 228; estimate of, 332.
Conger, Hon. O. D., speaks in favor of Eads's proposition, 64.
Congress, bill passed by, to appoint Commission 1874, 48; bill passed by, to improve S. Pass, 60; appropriations voted by, 1878, 171; relief to Eads appropriated by, 202.
Conditions changed by jetties at mouth of S. Pass, 233.
Construction, cheaper methods devised by Eads, 67; rapid, demanded, 81; progress of, discussed by, 1879, 341-344.
Continent, half, embraced by river and tributaries, 2.
Corthell, E. L., details of instruction intrusted to, 82; controverts Howell's statements, 99; promoted, 147; letter of, for Advisory Board, 270; letter of, refuting Howell's statement, 281, 282.
Craig & Righlor, contract of, 18.
Craighill, Col. Wm. P., board, 1874, 21, 247
Crevasse, Cubitt's, 15; Bonnet Carré, 31.
Cribs, spur, 207; palmetto, 207; described, 207.
Cromwell S. S. Line uses jetty channel, 116; passage of jetties by, necessary, 117.
Cross-Section, area of, greater in jetties than in pass, 73
Current, littoral, velocity of, 43, 44; flow of, directed against littoral, 74; changed by jetties, 214; velocity of, in pass, 217; crevasse affects lead line, 222; littoral, discussed and facts stated, 233.
Curves, various, 217; dependence of, on Carrollton gauge, 218.

Dam, Kipp, recommendations about, by Advisory Board, 268.
Dam, Island, length and description of, 125.
Dam No. I., description of, 124-126; effects of, 126; estimate of cost of, 296.
Dam No. II., description of, 127.
Dam, Upper, description of, 182.
Danube, sediment of, compared with Mississippi, 45; sediment of, proportional to volume, 46; delta, bars and jetties of, described and discussed by Sir Charles A. Hartley, 52-55; compared with Mississippi, 55-58; works on, successful, 272; delta of, similar to Mississippi, 272; depth attained at, 272.
Delta of Mississippi, history, growth, regimen, 8; process of formation of, described, 11; compared with highlands, 69; more favorable to improvement than Danube, 272.
Demarcal, N. O., Howell's and Eads's letters published by, 278-281; editorial of, 291-293.
Deposits, in 1875, 95; in 1876, 95; on seaside of jetties, 157; in channel, during its formation, 226.
Dippold & McDonald, stone furnished by, 209.
Discouragements stated in Eads's letter, 150.
Donovan, C., complimented, 240.
Dredgeboat, necessity for, 158; "G. W. R Bayley" described, 159-165.
Dredgeboats, Government, 18; depth obtained by, 119; "Macaulester" and "Essayons" described, 129; opposed to correct principles, 159.
Dredging, at head of S. Pass, 136; Commission on, 1877, 166; material removed at jetties by, 214; by chains, harrows, and ploughs, 214; Grant's machine described, 215.
Driver, sheet pile, described, 84.
Drina, river and jetties, 50.
Dyke, Cross, length and location of, 123; causes of disaster to, 123.
Dyke, East, advised by Advisory Board, 113; location of, described, 114; abandoned, 114; effects of, 114.
Dyke, Island, description of, 128; destroyed, 178, 179; rebuilt, 1879, 181; down-stream extension of, 182.

Dyke, Lighthouse, extension of, 133; damaged by current, 134; rebuilt, 1877, 177.

Eads, James B., address of, before Merchants' Exchange, 1; biography of, 23; declares in favor of jetties, in May, 1873, 24; offers extraordinary inducements on account of hostility of Government engineers, 25; makes formal proposition to deepen S. W. Pass, 25; contends alone against opposition, 28; addresses letter to Windom, 28; states jetties not been tried, 37; reviews Humphreys, May 29, 1874, 43; makes proposition to deepen S. W. Pass, 62; speech of, at banquet, 1875, 66; absence of, from jetties, 1875, 81; letter to Patterson, March 7, 1876, 98; letter to Taft, May 24, 1876, 103; his requests, 105; decides plan for head of passes, 113; letter to Secretary of War, May 7, 1878, 168; letter to Robertson, reviewing Humphreys' letter, 172; submits drawings and estimates to Board, 1878, 191; reviews report, 194-196; theories of, proven by results, 219; tribute to, 241; authorized to build jetties, 261; letter to Secretary of War, May 23, 1876, 278; letters to Patterson, 279-280; makes requests of Secretary of War, 283; letters in N. O. papers, 289-291, 293-295; letter of, to Secretary of War, April, 19, 1877, 304-308; May 7, 1878, 309-313; answer of, to Humphreys' letter, June 1, 1878, 335-339; letter of, to Board 1879, 337-341; reviews report of Board 1879, 357-367.

East Point, zero for all distances, 84.

Edwards, Joseph, constructs pumps for "Bayley," 161.

Elevator, steam, for concrete, 189.

Embarrassments, work hampered by, 155.

Employees work for certificates, 156; list of, deserving mention, 376.

Engineer-in-charge, daily work of, 82.

Engineers, Civil, national works in Europe intrusted to, 26; support Eads's views, 47; favor jetty plan, 239; American Society visit jetties, 239.

Engineer Corps, jetty, efficiency and faithfulness of, 296.

Engineers, Military, national works in their charge, 25; oppose Eads's proposition, 1874, 26; oppose giving improvement to an outsider, 47; none favor jetty plan fully, 197; hostility of, compelled severe provisions in act, 366.

Erosion of banks not dependent on friction, 29.

Estuary, ancient, of Mississippi, 10.

Exportation of products increased by jetties, 255.

Forshey, C. G., opposes jetties before Congress, 38-40.

Francis, Capt. R., pilots S. S. *Hudson* through jetties, 108.

Francis, St., The, description of, 5.

Freights reduced by jetties, 236.

Gager, Capt. F. V., commanding S. S. *Hudson*, enters jetties, 108.

Geographical location of jetties, 377.

Gillmore, Gen. Q. A., on Board, 1874, 21, 247.

Grafton, steamboat, arrived at Port Eads, 75.

Grain not heated since construction of jetties, 237.

Grand Bayou, half way up the pass, 70; Eads intended to close, 73; closure of, and effects, 119; dam at, described, 139; results of dam, 141.

Grant from U. S. to Eads, authorizing jetties, text of, 261.

Grant, Capt. John, constructs machine for deepening channel at head S. Pass, 215.

Gravel for concrete, 203; worked into mattresses, 208.

Gulf, depth of, 10; inland sea of salt water, 14; no barrier to current, 34 (see *bar, outer slope of*, for changes made by jetties); changes in greater depths of, 221; survey of, 222; results in, discussed, 231.

Hartley, Sir Charles A., abstract of his two papers on Danube jetties and discussion, 53-58; member of Advisory Board, 92.

Head of Passes, problem of, 110; conditions of, described, 112; extent of works given, 119; principle of works stated, 120-122; results of works, 1877, 137, 138; résumé of works given, new works described, 175; final results of works, 183; economy and extraordinary effects of works, 184, 185; general results given, 223; works at, enumerated by Board, 1879, 343, 344.

Head of South Pass, bar of, described, 112; development of channel, 137; work delayed by finances, 156; attempt to deepen by current machine, 215; bar at, wearing away, 258; shoal at, discussed by Board 1876, 300.

Head of Water at Kipp Dam, 88; current created by, through west jetty, 89.

Hebert, P. O., opposed jetties before Congress 38-40.

Hilgard, E. W., classified silts to find law of deposit, 34.

History of jetties, reasons for writing, given, 3.

Hostility of Government engineers compelled Eads to raise additional means, 68.

Howell, Maj. C. W., on Board of 1873, 21; states that conditions for success by jetties do not exist, 36; assistant of, makes survey, 97; writes letter for *N. O. Democrat*, 99; on Board, 1874, 247; publishes letter about jetties, 278-287.

Hudson, S. S., entered jetties, 108.

Humphreys, Gen. A. A., approves report of Board, 1874, 21; replies to Eads, May 22, 1874, 36; takes issue with Eads's views, 41; opposes Eads's proposition, February, 1875, 63; published memorandums, 104; interdicted from further interference, 106; writes letter to Robertson, 1878, 171; his predictions not fulfilled, 234; memorandums of, 285; interference with jetties, 286; letter of, to Robertson, 320-324.

Hydrometrical table of data, 377.

Impervious, jetties are not, 157.

Injury to jetties, penalty of, 264.

Inspecting officer instructed by Secretary of War, 106.

Instructions of Eads to assistants, 81.

Jetties, Mississippi, world affected by, 1; will not back up water, 34; should be parallel, 34; European, 50-59; Commission of 1875 give reason for application of, 61; also prefer them to ship canal, 62; location of, at South Pass, 73; width between, 73; first effects of, 93; general problem of, 111; described, 147-149; height of, 208; impervious by deposits, gravel, etc., 230; commercial benefits of, 235-238; principle of, maintained forever, 241; designed by Board, 1874, 244; estimate of, by Howell, 245; difficulties of, enumerated, 246; advantages of, stated by Barnard, 248; European, 252, 253; principle of, explained by Board, 1875, 253; specifications of, 257; estimates of, 258; compared with canal, 259; width between, 266; less difficult to

construct than European, 271; progress of, 342; results in front of, 356.
Jetty, East, alignment of, 75; depth of water on line of, 86; alignment of, recommended by Advisory Board, 206, 207.
Jetty System, economy of, dependent upon rapidity of construction, 81.
Jetty, West, guide piling of, commenced, 86; work on, suspended, 86; alignment of, 87; length of guide piling, 87; mattresses, width of, 89; depth of water on line of, 89; when raised to surface, 89; alignment of, recommended by Advisory Board, 207.
Johnson and Wilson furnished cement, 304.
Jump described, 76; mattress ways at, 77.

Key, experiments with, by Forshey, 44.
Kimball, S. N., contract given to, to dredge head of pass, 136.
Klapp Dam commenced, 87; damaged by current, 88; reconstructed, 89.

Land made by deposits of sediment, 213.
Leakage through jetties, and effects of, 90.
Lighthouse, view from, 69.
Lines, head and bridle, in mattresses, 78, 79.
Loan aided by S. S. Hudson, 109.
Losses, U. S. not to be liable for, 265.
Lumber, total amount used, 209; where obtained, 309.

Mans, river, jetties at, described, 50.
Macadam, described, 303.
Maclay, W. W., report of, on cement tests, 264.
Macomb, Gen. J. N., on Board 1878, 191.
Maintenance, conditions and payments, 14, 262.
Marindin, H. L., surveying party in charge of, 71; makes survey, 1876, 98.
Marsh, material of soft, 71.
Massachusetts, Miss. valley compared with in size, 2.
Materials, total estimate of, 332.
Mattress, described, 76-80; patented, 80.
Mattresses, willow, most important part of jetties, 75; how plotted, 84; size of, 84; used to prevent scour at sheet piling, 86; west jetty, 89; built on barges, 148; built in place, 148; built on skids, 149.
Mattress work at Mans, estimate of Commission, 1875, based on, 67; essentially the same as the Mans, 267; detail cost of, 275.
McCreery, G. W., Secretary of War, transmits report of Board of 1879, 325.
McHenry, J. Sharp & Co., furnished stone, 309.
Mean embarked by Eads's associates, 67.
Meigs, Col. Wm. E., on Board, 1878, 191.
Meteorological, 277, 278.
Mississippi River Improvement Commission, pretext for attack on jetties by Humphreys, 171.
Mississippi, description of, 6; ancient map of, 8; early discoveries of, 9; origin of name, 9; changes in, 9; volume of, 13; lower, range of between high and low water, 14; upper, identity preserved in main river, 35; compared by Hartley with Danube, 56, 57.
Missouri, the description of, 4.
Mississippi Levee Law, Wait, Howell refuted, 108.
Mitchell, Prof. Henry, member Advisory Board, 92; member of Board of 1875, 49.
Mixer, concrete, described, 189.
Models of jetty channel, 234.
Modelling R., plan of, for ship canal, 20.
Mud lump blockade, placard of Hebert and Forshey, 40; analysis of material in, 154.

Navigation, record of, 235; table of, 375.
Nelson, Capt. Wm. S., death of, and memoir of, 187.
New Orleans, business men of, oppose jetties, 37; sentiment of, changed, 63.
New Orleans S. S. passes through jetties, 116.
Newton, Gen. John, on Board of 1874, 21, 247.
Newton, "Vena Contracta" of, illustrated, 151.

Obstructions, natural, commerce imprisoned by, 3; history of attempts to remove, 17.
Oder, jetties of, 50.
Ohio river, description of, 4; obstructed by mountain ranges, 10.
Opposition, effects of, by government officials, 118.
Originality, claim of, by Board, 1878, 194; discussed by Eads, 195, 265.
Outlet, created and maintained by jetties, 1; necessity for, 6, 7; permanent plans for improving, 19; natural deepening of, advised by Board, 1875, 255.

Palmetto-logs, used for cribs, 207.
Parapet on concrete blocks, 208.
Parmely, O. D., death of, by yellow fever, 187.
Passes, dimensions of, 15; phenomena of, explained, 32.
Pass à Loutre selected by Board, 1874, 244; less advantageous than S. Pass, 246.
Pass, South, estimate of jetties at, by Commission, 61; Eads objects to, before Commission, 63; course of, described, 70; width of land on each side of, 70; bar of, described from U. S. Coast Survey, 72; changes in, and materials secured from, 229; selected by Board, 1875, 256; fitness of, for navigation, 271, 272.
Pass, Southwest, bill for improvement of, reported favorably by House Committee, 64; channel of, maintained by dredgeboats, 117; cost of maintaining channel, 262.
Patterson, C. P., Supt. U. S. Coast Survey, refuses to order survey, 98; refuses to give result of survey seaward of jetties, 101; gives result by instructions from House of Representatives, 102; letters to and replies by, 279, 280, 283, 284.
Payment of twenty-foot channel delayed, 146; of bills extended, 155; modification in terms of, 193, 201; recommendations of, by Board 1878 objected to by Eads, 201; specified in grant, 262, 265; modification of terms of, discussed by Board of 1879, and Eads, 339, 351 353, 361 363; terms of, amended by act March 3, 1879, 368, 369.
Pay-rolls, overdue, 155.
Permanency, report on, by Commission, 1877, 168; 1876, 301; probable, 193, 350, 351, 357, 358.
Pier Head, cast jetty, 208; plan for, advised by Advisory Board, 209.
Physics and Hydraulics, authority for statements, 15; objections of, to jetties discussed by Barnard, 248.
Piles, distances between, 75; simply guides, 75; jetty, finished driving, 84; sheet, described, 84; washed out, 85; length of, on west jetty, 87; record of driving, 154.
Piling, alignment of, established, 75; on river side of jetties, 149.
Pilots opposed to jetties, 117.
Pilotown, residence of pilots, 117.
Pine, hickory, 78.
Pratt & Farrar furnished lumber, 209.
Pratt, Eads, Grafton arrived at, 75; view of, 210; advantages of, 211.







